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ABSTRACT

The countdown to a new century provides a unique opportunity to engage America's youth in charting a course for the future. The Mars Millennium Project challenges students across the nation to design a community yet to be imagined for the planet Mars. This interdisciplinary learning project aims to encourage K-12 students in classrooms and youth groups throughout the United States to achieve a better understanding of the connections between science and art, advance their technological skills, and gain an appreciation of the culture, history, and traditions of their own community. This booklet provides information and resources about the project that can be configured in many ways such as a single class project or one that involves several classrooms. (Contains 40 references.) (ASK)

The Mars Millennium Project

A National Arts, Sciences, and Technology Education Initiative

National Aeronautics and Space Administration

NATIONAL ENDOWMENT FOR THE ARTS

THE J. PAUL GETTY TRUST

THE WHITE HOUSE MILLENNIUM COUNCIL

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What's Inside?

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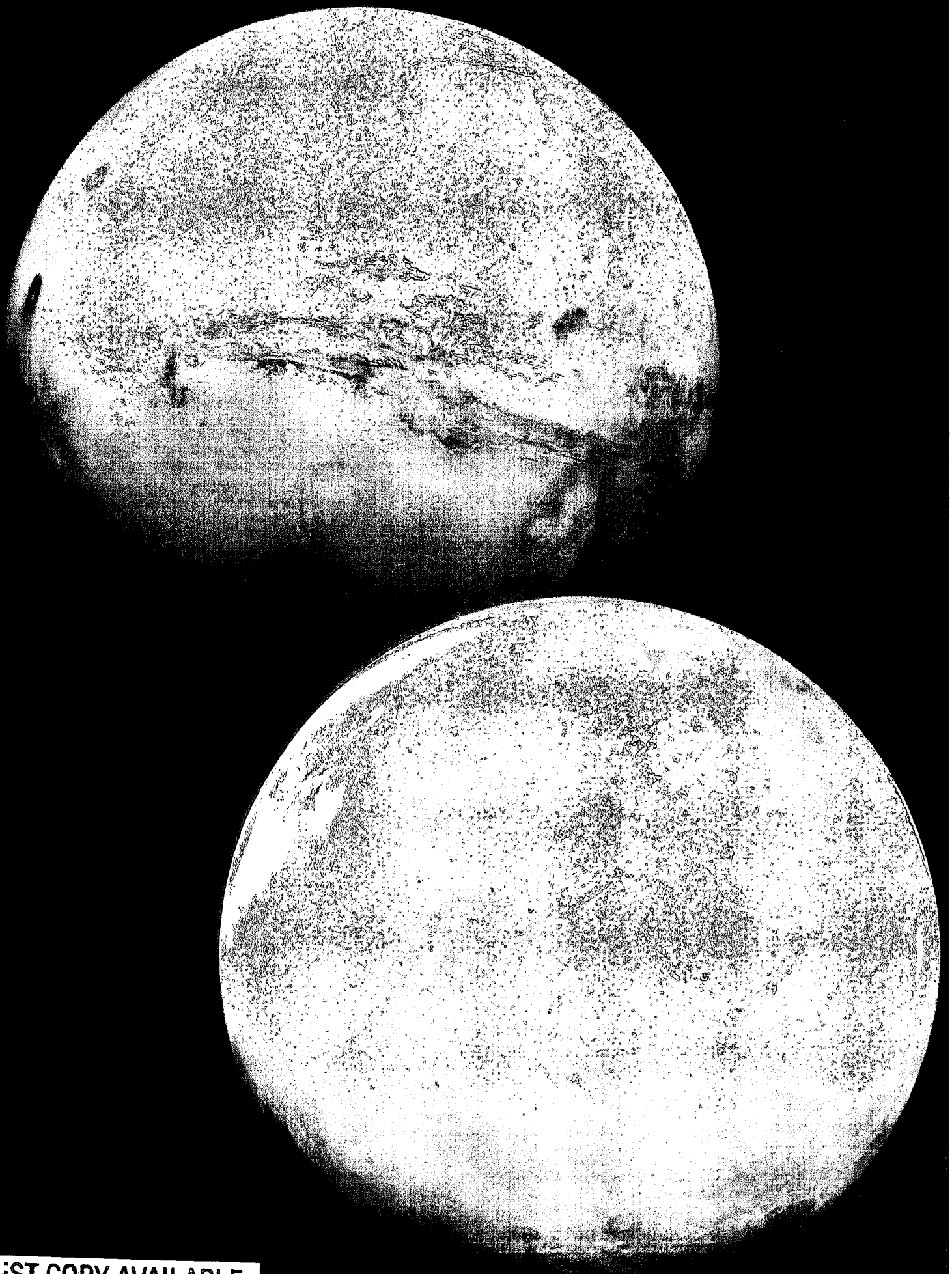


Letter from Our Sponsors

Dear Mars Millennium Participant:

The countdown to a new century provides a unique opportunity to engage America's youth in charting a course for the future. The Mars Millennium Project: A National Arts, Sciences, and Technology Education Initiative is an official White House Millennium Council youth initiative that challenges teams across the nation to design a community yet to be imagined on Mars.

This interdisciplinary learning project will engage 5- to 18-year-olds in classrooms and youth groups throughout the United States. Working in teams and with educators, community leaders, and professionals in many fields, hundreds of thousands of young people will investigate the best of the past and present, and apply what they learn to the plans for the future. The result: a design for a new community—one that is scientifically sound and offers a high quality of life—and one in which they would be proud to live.

By participating in this groundbreaking project, children in schools, clubs, and other organizations throughout the country will achieve a better understanding of the connections between science and art; advance their technological skills; and gain an appreciation of the culture, history, and traditions of their own community. Their designs will be exhibited in public settings across the country, and their ideas will be sent to Mars on a microchip aboard a future NASA mission vehicle.

Guiding the Mars Millennium Project are the U.S. Department of Education, the National Aeronautics and Space Administration, the National Endowment for the Arts, and the J. Paul Getty Trust. A host of public and private organizations along with some of the nation's leading corporations and businesses are also taking part, making this project a true community effort.

The project can be as simple or as involved as you wish. The process asks you to Reflect, Imagine, Discover, Create, and Share. You are free to accomplish those steps and answer the important questions of the project in any manner and through any process you find suitable. You may work on it for a year or for a few weeks, engage in detailed research or simply read a few books. Just remember that all project submissions must be registered with *Mission Control* by June 1, 2000!

We are very pleased that so many Americans are organizing activities that will bring their communities together to learn from the past, to celebrate the present and to create a positive future together. We look forward to working with you in a spirit of remembrance, hope, and celebration.

U.S. Department of Education
National Aeronautics and Space Administration
National Endowment for the Arts
J. Paul Getty Trust

Welcome to Mars2030

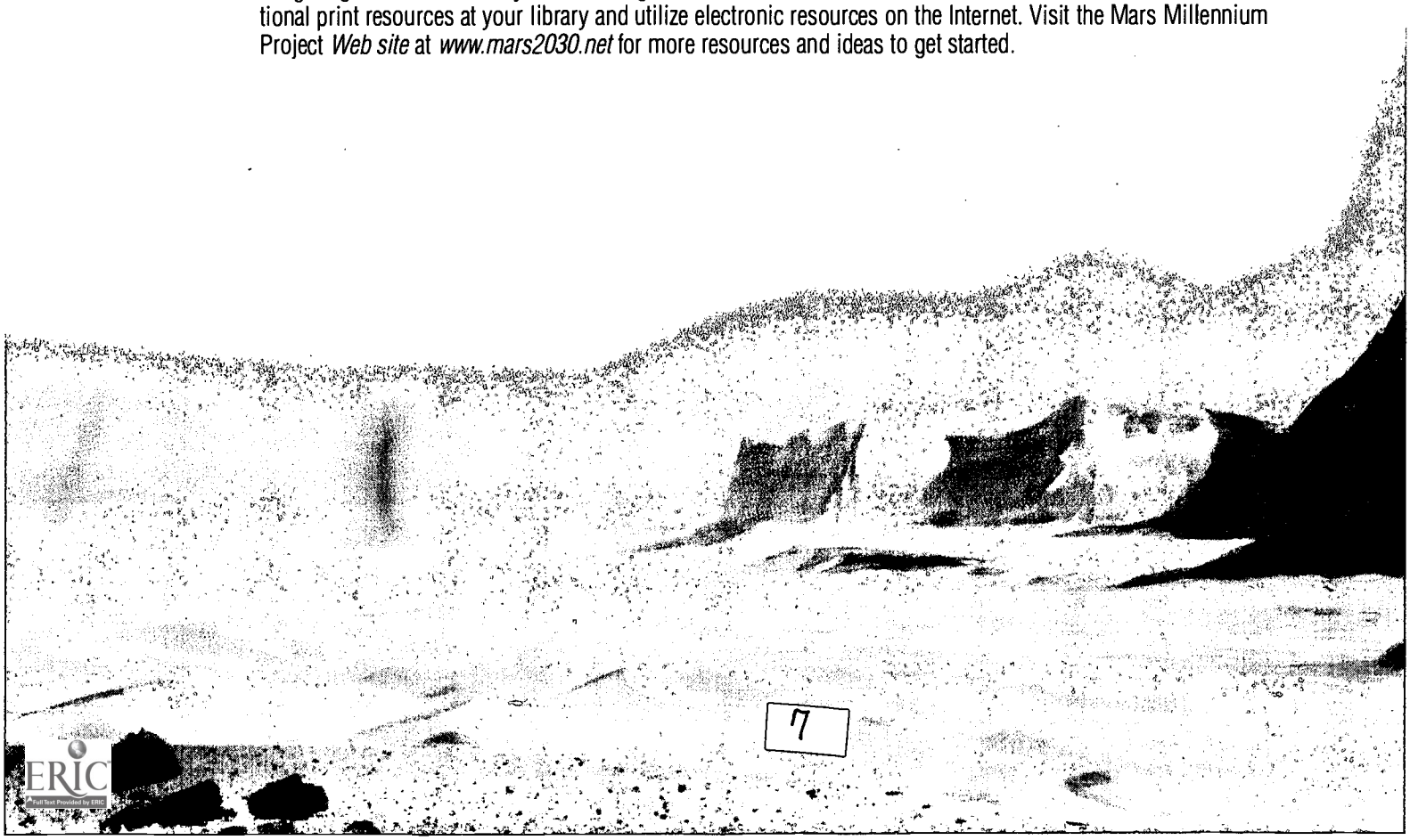
Your Mission:
To imagine and design a community for 100 people arriving on Mars in the year 2030

The Mars Millennium Project: A National Arts, Sciences, and Technology Education Initiative (Mars2030) is an easily adaptable initiative designed to help America's youth appreciate their communities and focus on a positive future. *Mars2030* can be configured as a project in many ways—as a single class project or one that involves several classrooms; as a grade level or schoolwide project; as teams working on one aspect of the community or interdisciplinary groups working across subjects to tackle how an entire community will look. The project can last for a day, a week, a month, or a semester, or be a club's special project for fun or merit. We encourage you to use the project to create partnerships with others in your community or other communities on-line, and engage your community by sharing your ideas with civic leaders and media.

Five Simple Steps

1. Reflect... on what you value about your community.
Stop and look around you. What is your community like? What makes a community? What do you value about your community? How is it designed? Why is it unique? What's good about living there and how would you describe your community to others? Develop a team, or teams, to work on the project.

2. Imagine... a community on Mars in the year 2030.
Have the participants talk with parents, grandparents, and other relatives about your community. They may want to interview civic leaders, city planners, architects, and others about what makes your community unique. Discuss and decide on a name for your Mars community. Find out what it would take to survive on Mars. Lead your team in imagining what a community on Mars might be like. Check out the *Activities and Resources* section to find additional print resources at your library and utilize electronic resources on the Internet. Visit the Mars Millennium Project *Web site* at *www.mars2030.net* for more resources and ideas to get started.



Welcome to Mars2030

3. Discover... the planet you live on and the planet on which you will live.
Round out this millennium by learning more about Earth and Mars. Participants may want to learn from scientists, architects, engineers, and artists; take field trips to museums and libraries; and engage community leaders. Take what the *Project Team* learns and apply it to designing a new community.

4. Create... a community for the 21st century.
Design a new community by creating a visual representation of that community or any scientific or artistic aspect of it, then write about the challenges you faced in creating that community. Your team may want to create and visualize their entire new village while other groups might choose to explore one specific part of community life as shown through an artistic or scientific approach. The project's flexible approach allows your team to move in many directions.

5. Share... your vision and ideas with the world.
We will help you share your ideas through the *Mars2030 Virtual Gallery* and make you eligible for exhibits being planned around the nation. Resources are available to help you display your project in your community. Registered submissions will be placed on a microchip for transfer to Mars on a future NASA mission. Your group's submission will also make it eligible for a host of special *Project Extensions* sponsored by national organizations and private sponsors.

******MISSION ALERT******
All project submissions must be registered with Mission Control by June 1, 2000!

Welcome to Mars2030

Your User-Friendly Mars2030 Participation Kit

organized into [5] easy-to-use components:

- Participation Guide
- Activities
- Resources
- Data Forms
- Key Words

1. Participation Guide
Mars2030 has been designed to blend easily into or supplement your regular lesson plans or club schedules. This *Participation Guide* contains all the information you need to complete the project:
- step-by-step instructions for completing the project (*Mission Guide*); and
- sample project approaches.

2. Activities
The Activities raise big questions that will lead you to engaging, exciting, and creative sessions with your participants.

3. Resources
Mars2030 Project Sponsors, Cooperating Organizations, and Contributing Partners have developed a variety of valuable resources and *Project Extensions* of which you may choose to take advantage. In keeping with the project goal to enhance technology skills, most of the information can be found on-line at *www.mars2030.net*, where you can link to hundreds of different and interesting *Web sites*.

4. Data Forms
The three perforated *Data Forms* in the back of this booklet will help you prepare your project for official registration on-line. All projects must be registered by June 1, 2000.

5. Key Words
Key Words, found in *italics* throughout the text, can be found on page 31 of this booklet. If you are confused about any terms used in the guide, look here for answers.

Project Guide Objectives

- To enrich and supplement your existing classroom or club activities;
- To engage America's youth with their communities, "honoring the past and imagining the future"; and
- To connect with others by working toward a common goal and positive future.

Mission Guide

As the *Project Team Supervisor,* your job is to lead your *Mission Specialists* through the five steps of the Mars Millennium Project and acquaint them with resources for learning, researching, and creating a project. The goal for teams is to consider what it will take to achieve a livable and life-sustaining community on Mars that is culturally and artistically rich. *Project Teams* will then create a visual representation of such a community or any artistic or scientific aspect of it.

Step 1... Reflect

Explain to your *Mission Specialists* that this project is the White House Millennium Council's lead youth initiative and is sponsored by the U.S. Department of Education, the National Aeronautics and Space Administration, the National Endowment for the Arts, and the J. Paul Getty Trust. Some of America's leading organizations, clubs, and businesses are lending their support for the project and will provide valuable resources to *Project Teams.*

Now is the time to assemble your *Project Team.* You may want to consider the division of work, how decisions will be made, and other important organizational and procedural questions.

Let your *Mission Specialists* familiarize themselves with their crewmates, learning each others' diverse strengths and backgrounds. In space, working together and working effectively are critical, so have them work closely with you and with other *Project Team* members.

Now is the time for *Mission Specialists* to ask themselves important questions about their own community such as: What is my community like? What makes a community? What do I value about my community? How is it governed? Do citizens have responsibilities? How is it designed? Why is it unique? What's good about living there, and how would I describe my community to others?

L a u n c h imaginations!

The Mars Millennium Project leads you and *Project Team* members on an interdisciplinary mission that integrates science, art, and technology and helps young people think about what it means to learn and live in an increasingly complex world.

Step 2... Imagine

Having learned more about their community, the *Project Team* members can now imagine a community that represents all *Mission Specialists* on Mars. To do this, team members must take their knowledge of their own communities and determine how a new community might need to be different to adapt to life on Mars. Your *Project Team* might want to consider the questions posed in the *Activities and Resources* section. Members may also want to:

- Pick a name for their community. All Mars Millennium Project communities must register their *Mission Name*. They may also wish to design a flag, symbol, or emblem for their community;
- Consider how they could represent the many members of their community in the 100 people chosen to live on Mars;
- Work with *Project Team* members to design and develop a mission patch. While in training, the crew of each NASA Space Transport System designs a patch that identifies its specific mission. Each crew member has an important role, and the patches always include last names of all the crew members.
- Research astronauts and space missions and previous explorations by visiting libraries and museums, and watching educational programs. Find out about other missions that have been launched into space, and the challenges those missions faced; or how explorers of the Earth's deserts and polar caps have dealt with extreme conditions. Learn about astronaut training and imagine how inhabitants on Earth would prepare themselves for life on Mars. Learn what tools, supplies, and personal belongings astronauts have taken into space, and have *Mission Specialists* think about what they value and might want to bring to Mars;
- Talk to their parents, grandparents, teachers, experts, and others in their school, places of worship, and community as a whole. Ask questions and find out what it is that makes their neighborhood special;
- Ask friends and neighbors what they would want most if they lived on Mars. Look around their homes to see what is important to their family. Ask them to identify the five items they would take with them to reflect their home and neighborhood;
- Talk to their city council, mayor, state legislator, or other representatives to learn about how their community leaders are chosen, how their community is managed, and how services are provided. How might 100 people get along together on Mars?

If your team has access to the Internet, the *Project Team* may want to post messages on the Mars Millennium Project *Web site* (http://www.mars2030station.net), asking others what they have learned about their communities, and chatting with experts who will be available on-line about science, technology, the arts, and culture. Check out the *Web sites* of the *Cooperating Organizations* for more information and resources.

Step 3... Discover

Discovery and research can be an empowering experience for all *Mission Specialists*. Surviving and thriving on Mars will mean adapting to the elements and creating a community where life can be enjoyable on a faraway planet. How do we survive on Earth, and what will we need to survive on Mars? It is the job of the *Project Team* to develop an understanding of these questions as members set out to create a community on Mars. *Mission Specialists*, alone or as a *Project Team*, should go to their library, watch educational programs, and take field trips to museums to learn about what may be needed to design a thriving community on Mars.

Here are some ideas on how to prepare your *Mission Specialists* for project launch. *Mission Control* encourages original approaches, so do not feel limited to these few ideas. Create a unique path to discovery that best meets your situation and community.

- Research art that depicts or evokes Mars. Check out images from space missions such as Mars Pathfinder or the Hubble Space Telescope. Help the *Project Team* understand the visual and performing arts that people around them create to express and enrich life. For more information about how to integrate the arts into your project, use the Getty's ArtsEdNet at (http://www.artsednet.getty.edu/), the NEA's Art Forms at (http://arts.endow.gov/artforms/), or the Kennedy Center's ArtsEdge at (http://artsedge.kennedy-center.org/).
- Have the *Project Team* seek out scientists, artists, other citizens, and leaders who understand issues key to the project in order to learn how to solve problems the *Project Team* might face. The Mars Millennium Project *Web site* (http://www.mars2030.net) has message boards, downloadable resources, and chats with experts in many fields and with other teams. Check in regularly for updates.
- Go to NASA's *Web site* (http://www.nasa.gov) to learn about space travel, and visit the Jet Propulsion Laboratory's *Web site* (http://www.mars.jpl.nasa.gov) to learn about Mars robotic missions such as the Mars rover.

Is Mars Still Mars by a Different Name?
Greek — Ares
Babylonian — Nergal
Egyptian — Harmakhis
Roman — Mars
Scandinavian — Tyr
Norse — Tiu
Olde English — Tiw
Persian — Phlavani Siphir

Step 4... Create

The design phase of the project allows for maximum flexibility and creative thinking. Complete the following two steps to create a community for the Mars Millennium Project:

- Your *Project Team* must create a visual representation of the community or a portion of the community. Some aspects you might have the *Mission Specialists* include are (but are not limited to) your community's flag, emblem, or trademark; a mission patch; a song or dance representing the community; a painting or an abstract sculpture that represents their ideas; an illustrated equation, model, or scientific formula; a depiction of the entire Mars community; or a three-dimensional model of the community. See *Data Form*, Part 2 for more details.
- Your *Project Team* also needs to compose a written summary of the challenges faced while designing a community. To do this, members should keep in mind not only questions brought up in the *Activities and Resources* but also questions and challenges they encountered as they worked. See *Data Form*, Part 3 for more details.

We encourage all ideas for a complete community or any artistic or scientific aspect of such community.

******WARNING! AVOID MISSION CANCELLATION******

If you do not complete the next step, your *Project Team* will not be eligible to participate in any of the nationwide culminating events and will not have the opportunity to share its vision with others!

Today's kids
are the scientists,
computer programmers,
and artists of the
next century.

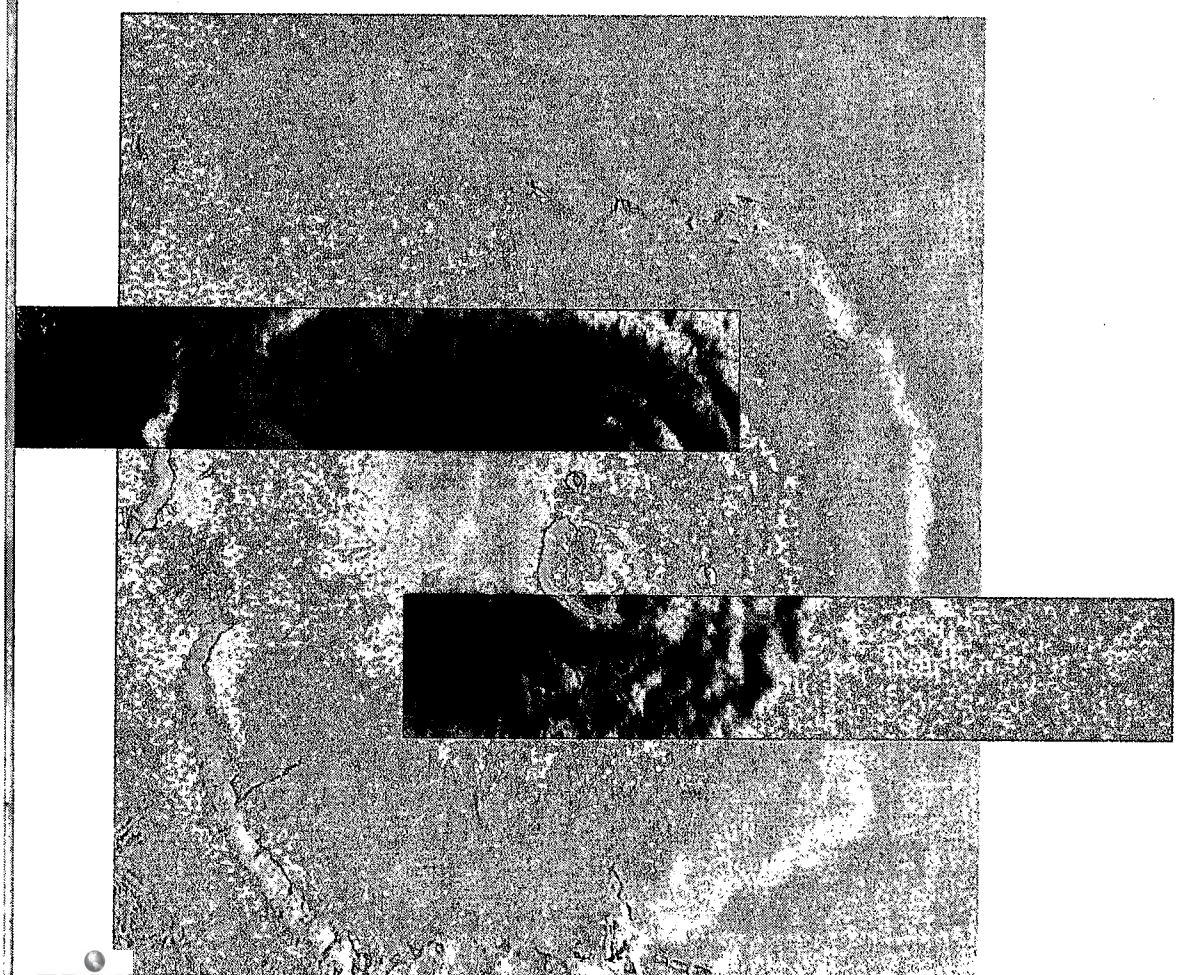
Step 5... Share

Now it is time to share with *Mission Control* your *Project Team's* solutions to the challenges of living on Mars. Complete all three parts of the *Data Form*.

- Complete Part 1 of the *Data Form*. Remember to include your community's unique *Mission Name*!
- Take a photo of your visual representation of the entire Mars community or one artistic or scientific aspect of your community. Submit in the format of slides as explained in Part 2 of the *Data Form*.
- Write answers to the questions describing the *Project Team's* community as detailed in Part 3 of the *Data Form*. Have your *Mission Specialists* participate in discussions and debates to come to conclusions that represent the project.
- The *Project Team Supervisor* should submit all data, including the Official *Data Form*, Parts 1, 2 and 3, to the project *Web site* at *www.mars2030.net*. All data must be received by June 1, 2000, to be eligible for inclusion in any culminating events.

Project Teams that complete all the steps will be eligible to participate in culminating events and all *Project Extensions*.

We encourage members to ask the local school board, city council, museum, library, nearby planetarium or chamber of commerce to display your Mars community. Many of them have already expressed an interest in doing so. You could have your *Mission Specialists* show their projects at science fairs, art fairs, local festivals, or other events. Remember, you have completed an important project, so show it off! You can find organizations on the Mars Millennium *Web site* that may help you display your project.



Resources: Web Site

www.mars2030.net
Your Gateway to the Mars Millennium Project

Mars2030.net is the gateway to the complete on-line presence of the Mars Millennium Project. The site also helps you complete your project by allowing you to submit your entry via the Web. At the site, you can chat with astronauts, meet fellow *Mission Specialists* and interact with other *Project Teams*, research scientific and artistic questions, and much, much more!

Mars2030.net—Innovative Design

Selected to design the Department of Education's Web environment for the Partnership for Family Involvement in Education, Copernicus Interactive, sponsored by *USA TODAY*, brings *mars2030.net* to you with exciting resources and innovative content. The site is a virtual education community in cyberspace, drawing on support from prestigious organizations, including America Online (AOL) and The Planetary Society.

Mars2030.net—Facts About the Project

With access to learning resources, links to *Cooperating Organizations* across the nation that support the project, and buttons that take you to the *Web sites* of the *Project Sponsors* and *Contributing Partners,* there's nothing about the project you can't discover on-line!

Mars2030.net—Exciting Learning Resources

The center of the Mars Millennium Project *Web site* is a window to the stars—four windowpanes through which our imagination can see a limitless future. One windowpane is *Mars*, authoritative scientific information about the planet provided by the National Aeronautics and Space Administration. Another pane, brought to you by The Planetary Society, is *Artists, Scientists and Astronauts,* inspiration and ideas from those who dream of and study space—and who have been there! Additionally, you can learn even more from the submissions of fellow project participants in the *Virtual Gallery* hosted by AOL. Don't miss the exciting *Chat and Interact*, on-line assemblies and opportunities for sharing ideas with others. Add to this resources from more than 100 national organizations, and *mars2030.net* provides a one-stop shop for information and ideas.

Mars2030station.net—New and Fascinating Communities

Technology is seen as an opportunity for learning communities of tomorrow. *Mars2030station.net* is Copernicus Interactive's collaboration station for Mars Millennium Project participants that opens up new ways to build education communities. This interactive site provides access to threaded discussion boards, events, galleries, and message centers where you can chat with a pen pal or other *Mission Specialists,* interact with astronauts, artists, and scientists, join in on feature presentations, or link up with fellow educators and other *Project Team Supervisors*—all in your Mars virtual community. Visit the project-customized Copernicus home page to learn more about making *Mars2030station.net* part of your daily project involvement. Remember, as you learn about Mars, you can learn from each other and build a new community of students across the country!

Resources: Contributing Partners

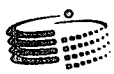
A Unique Partnership

The Mars Millennium Project is pleased to have the support of an outstanding group of private partners without whose help many aspects of the project would not have been possible. Please refer to *www.mars2030.net* as new partners join the project and offer special events and activities.

AOL.COM

America Online
(http://www.aol.com)
America Online, Inc., is participating in the Mars Millennium Project by creating a virtual gallery. The gallery will display on-line the completed work of the teams that are participating in the project.

America Online, Inc., is the world's leader in interactive services, Web brands, Internet technologies, and e-commerce services. America Online, Inc., operates two worldwide Internet services: America Online, with more than 16 million members, and CompuServe, with approximately 2 million members and several leading Internet brands, including Netscape.



Copernicus

Copernicus Interactive, Inc.
(http://www.copernicusnet.com)
Copernicus is the nation's K–12 Internet home page, the "starting point and connecting place" for K–12 education on the Web. Copernicus has joined forces with the Mars Millennium Project to create the project's informational *Web site* (*www.mars2030.net*) as well as the on-line community for project participants (*www.mars2030station.net*).

Discovery Channel
(http://www.discoveryschool.com/lessonplans/programs/destinationmars/index.html)
Discovery Channel School produces high-quality products and services especially tailored for the K–12 school market. Discovery Channel School's support for the Mars Millennium Project will feature Mars-related television programming and on-line support. A one-hour special program, "Destination Mars," will air throughout the fall on Assignment Discovery, and can be taped and used in classrooms for up to one year.

Additionally, *discoveryschool.com* will feature a number of free Mars-related activities for students and classes beginning in fall 1999 and continuing throughout the year 2000. The School Store area of the *Web site* features a library of space-related videos to support the teaching of space science.

Disney Adventures Magazine
(http://www.disneyadventures.com)
Disney Adventures is an entertainment magazine for kids 6–12 that reaches more than six million readers every month. As part of the Mars Millennium Project, *Disney Adventures* will run a contest in the September 1999 issue asking kids to submit their plans for an imaginary village on Mars. The winner will have his or her entry published in the December 2000 issue of *Disney Adventures*.

Binney and Smith
(*http://www.crayola.com*) and (*http://education.crayola.com*)
Binney & Smith Inc., maker of Crayola children's art products, is pleased to be a contributing partner to the Mars Millennium Project. The Crayola Dream-Makers program for the year 2000, "Millennium Odyssey," and a Crayola museum exhibit are two ways Binney & Smith is extending the Mars Millennium initiative inside and outside the classroom.

Lessons such as "Mosaics on Mars" and "Traveling Back and Moving Forward" from the year 2000 Crayola Dream-Makers guide were developed to help children carefully consider the values, ideas, and actions that shaped yesterday and today, and imagine those that will shape tomorrow.

Binney & Smith is extending the Mars Millennium Project beyond the classroom through a futuristic Mars Millennium-themed module contained within a 2,000-square-foot Crayola museum exhibit. This exhibit will travel to children's and science museums nationwide beginning January 2000.

M&M Chocolate Candy, Inc.
(*http://www.m-ms.com*)
The "M&M's"® Brand Character(s) representing the "M&M's"® Chocolate Candies are delighted to be part of the Mars Millennium Project. This global brand is more than 50 years old and has brought fun and pleasure to millions of consumers around the world. "M&M's"® Brand Character(s) have a unique appeal and are pleased to be able to communicate the Mars Millennium Project concept through their participation on over 650,000 Mars Millennium posters.

USA TODAY
(http://www.usatoday.com)
USA TODAY, the nation's newspaper, offers educators and students in grades 6–12 "The Experience for a Lifetime" by connecting the day's news to daily learning objectives. In more than 25,000 classrooms across the country, participants in the *USA TODAY* Education program receive a daily paper along with *Experience Today,* a daily educator activity guide. They also engage in a dynamic national on-line community, developed in partnership with Copernicus Interactive, for parents, students, and educators. This community will be connected to the Mars Millennium Project collaborations.

Resources: Cooperating Organizations

Links to America's Leading Organizations

More than 100 national organizations have joined in support of *Mars2030*. You will find interesting information and facts to help you through the project by visiting the sites of many of these *Cooperating Organizations* at *www.mars2030.net* on the Internet. In your community, contact local members of these organizations and encourage their participation and involvement with your *Project Teams*.

- Adler Planetarium — http://www.adlerplanetarium.org
- Aesthetic Education Institute
- Alliance for Arts Education/New Jersey — http://www.aaenj.org
- Alliance for Young Artists and Writers, Inc. — http://www.scholastic.com/artandwriting
- America's Promise — http://www.americaspromise.org
- America's Promise/Houston
- American Architectural Foundation — http://www.aiaonline.com
- American Arts Alliance — http://www.artswire.org/~aaa
- American Association of Community Colleges — http://www.aacc.nche.edu
- American Association of Museums — http://www.aam-us.org
- American Association of State Colleges and Universities — http://www.aascu.org
- American Composers Forum — http://www.composersforum.org
- American Federation of Teachers — http://www.aft.org
- American Institute of Graphic Arts — http://www.aiga.org
- American Library Association — http://www.ala.org
- American Symphony Orchestra League — http://www.symphony.org
- Americans for the Arts — http://www.artsusa.org
- Arts Education Partnership — http://www.aep-arts.org
- Artsgenesis — http://www.odesign.com/artsgenesis
- Association for Supervision and Curriculum Development — http://www.ascd.org
- Association of American Geographers — http://www.aag.org
- Association of Art Museum Directors — http://www.aamd.net
- Association of Hispanic Arts
- Association of Performing Arts Presenters — http://www.artspresenters.org
- Astronauts Memorial Foundation — http://www.amfcse.org
- Boys & Girls Clubs of America — http://www.bgca.org
- Business & Industry for the Arts in Education, Inc.
- California Arts Council — http://www.cac.ca.gov
- Center for Building Community
- Chabot Observatory & Science Center
- Challenger Center for Space Science Education — http://www.challenger.org
- Council for American Private Education — http://www.capenet.org
- Council of Chief State School Officers — http://www.ccsso.org
- Dance USA — http://www.danceusa.org/danceusa
- Discovery Museum — http://www.discoverymuseum.org
- Educational Theater Association — http://www.etaassoac.org
- Eisenhower National Clearinghouse for Mathematics and Science Education — http://www.enc.org
- Fernbank Science Center — http://www.fsc.fernbank.edu

Resources: Cooperating Organizations

- Girl Scouts USA — http://www.gsusa.org
- Grace Museum
- Greater Washington Urban League — http://www.gwul.org
- Industrial Designers Society of America — http://www.idsa.org
- Institute of Museum and Library Services — http://www.imls.gov
- International Council of Fine Arts Deans — http://www.icfad.wayne.edu
- International Planetarium Society, Inc. — http://www.ips-planetarium.org
- International Technology Education Association — http://www.iteawww.org
- John F. Kennedy Center for the Performing Arts — http://www.artsedge.kennedy-center.org
- Kennedy Center Alliance for Arts Education Network — http://www.kennedy-center.org/education/kcaaen/
- Kennedy Center IMAGINATION CELEBRATION National Sites — http://www.kennedy-center.org/education/kcaaen/aaeic.html
- LA's Best After School Enrichment — http://www.lasbest.org
- Learning for Life (Boy Scouts of America) — http://www.bsa.scouting.org
- Los Pleneros de la 21
- Montana Small Schools Alliance — http://www.mtsba.org
- Music Center Education Division
- National Alliance for Media Arts and Culture — http://www.namac.org
- National Aeronautics and Space Administration — http://www.nasa.gov
- National Art Education Association — http://www.naea-reston.org
- National Assembly of State Arts Agencies — http://www.nasaa-arts.org
- National Association of Counties — http://www.naco.org
- National Association of Elementary School Principals — http://www.naesp.org
- National Association of Female Executives — http://www.nafe.com
- National Association of Secondary School Principals — http://www.nassp.org
- National Association of State Boards of Education — http://nasbe.org
- National Catholic Educational Association — http://www.ncea.org
- National Civic League — http://www.ncl.org/ncl
- National Conference of State Legislatures — http://www.ncsl.org
- National Council of State Art Education Consultants
- National Council of Teachers of Mathematics — http://www.nctm.org
- National Dance Association — http://www.aahperd.org/nda/nda-main.html
- National Foundation for the Improvement of Education — http://www.nfie.org
- National League of Cities - http://www.nlc.org
- National PTA — http://www.pta.org
- National Science Foundation — http://www.nsf.gov
- National Science Teachers Association — http://www.nsta.org
- National Space Society — http://www.nss.org
- National Task Force on Folk Arts in Education — http://www.carts.org
- Neil Armstrong Air and Space Museum — http://www.ohiohistory.org
- North American Division of Seventh-Day Adventists — http://www.nadeducation.adventist.org
- North Central Regional Education Laboratory (NCREL) — http://www.ncrel.org
- NTC/Contemporary Publishing Group — http://www.ntc-school.com
- Ohio's Center of Science and Industry — http://www.cosi.org
- OPERA America — http://www.operaam.org
- Pacific Planetarium Association — http://www.ccsn.nevada.edu/other/Planetarium/PPA

Resources: Cooperating Organizations

- Partners for Livable Communities — http://www.livable.com
- Patuxent River Naval Air Museum
- Perpich Minnesota Center for Arts Education — http://www.ncae.k12.mn.us
- Robert H. Goddard Planetarium at the Roswell Museum and Art Center — http://www.roswellmuseum.org/planet/frm_plnt.htm
- Southeast Center for Education in the Arts — http://www.utc.edu/scea
- Teachers and Writers Collaborative — http://www.twc.org
- The American Federation of Arts
- The College Board — http://www.collegeboard.org
- The Galef Institute — http://www.galef.org
- The Mars Society — http://www.marssociety.org
- The Planetary Society — http://www.planetary.org
- U.S. Astronauts Hall of Fame — http://www.spacecamp.com
- U.S. Conference of Mayors - http://www.usmayors.org
- U.S. Space Foundation - http://www.USSF.org/
- United States Catholic Conference — http://www.nccbuscc.org
- Whitaker Center for Science & the Arts — http://www.whitaker.org
- Wolf Trap Foundation for the Performing Arts — http://www.wolf-trap.org
- YMCA National Writers Voice
- Young Astronauts Council — http://www.yac.org
- Young Audiences — http://www.youngaudiences.org
- YWCA of the USA — http://www.ywca.org

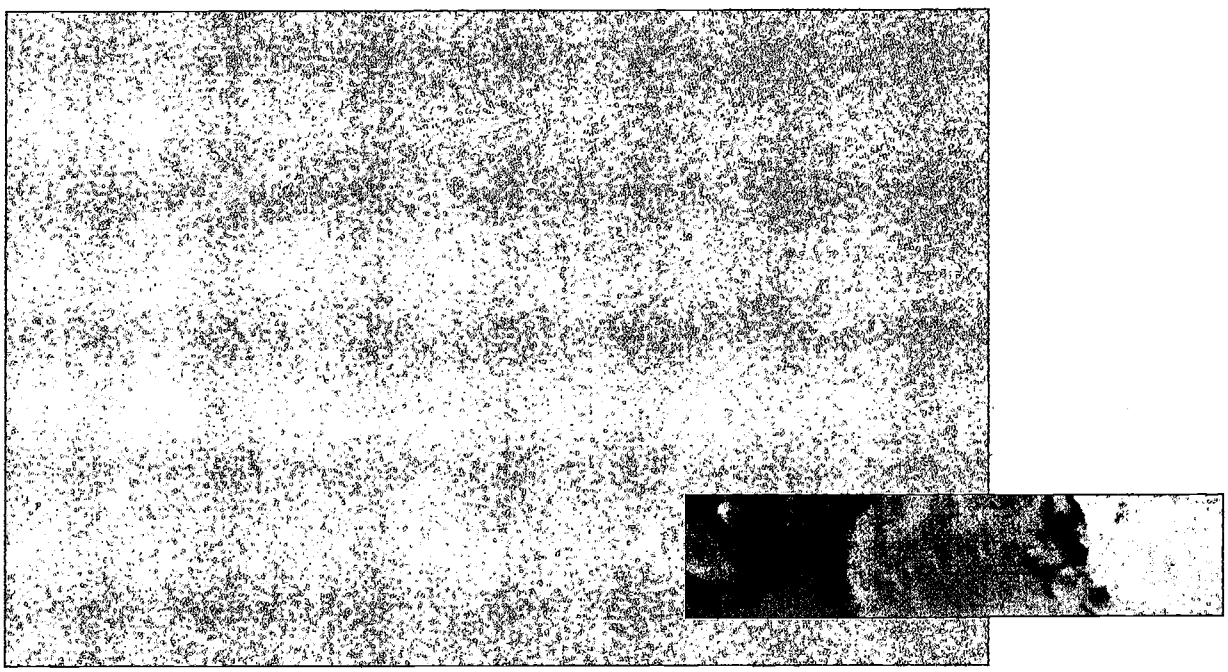
Continuing Support—
Please refer to the project web site at www.mars2030.net under the section *"Cooperating Organizations."* for an updated list of organizations and their web sites as they continue to sign-on in support of the project.

Resources: Participation Examples

Flexible, Adaptable, & Fun

The Mars Millennium Project is your chance to create a community yet to be imagined on Mars. Here are some ideas about how different organizations might treat the project, depending on the amount of time and resources available. First, some things to keep in mind:

- The project is designed to encourage reflecting, imagining, discovering, creating, and sharing. By spending even a small amount of time on the project, you will delve into some important issues about building a good community that will result in important lessons learned and project success.
- The following are *examples*. Please do not be limited to these ideas. Instead, integrate the project into your accepted course of study to meet the standards you have for your course or to design your own approaches.



Resources: Participation Examples

Example #1

Time: Maximum
Resources: Minimum

Mr. Campbell's Fourth-Grade Class, Lincoln Elementary School

Lincoln Elementary, a large public school, has large classes but few textbooks and little equipment. Mr. Campbell wants his entire fourth-grade class to work on the Mars Millennium Project for an entire semester.

Reflect: Because there are more than 40 children in Mr. Campbell's class, he assigns them randomly to several *Project Teams*. Some *Project Teams* elect individuals to take all the notes while, in other groups, everyone does a little bit of everything. Mr. Campbell likes the latter arrangement best, but wants all of his *Mission Specialists* to learn how to work together.

Imagine: Students in Mr. Campbell's class learn about the vibrant big-city community around them by speaking with their neighbors and families. They also go to the library and research urban communities and the history of their cultures. They decide to name their community Springfield, after Lincoln's home, and imagine that it will be as vibrant and diverse as their community on Earth.

Discover: The *Project Teams* go to the library and study the environment on Earth and Mars and the challenges of bringing necessities such as food, water, and air to the fourth planet. Mr. Campbell invites a former NASA engineer to speak to his class about how long it would take to get to Mars and how much they could bring with them.

Create: While designing scientifically sound communities, the *Project Teams* create dances and songs that would be sent from Mars to Earth so that family and friends back on Earth could understand how their culture was evolving on Mars and, in turn, those families and friends could send back similar artistic works that could keep the new Mars community up to date on Earth culture.

Share: After submitting the registration forms for his class, Mr. Campbell takes his entire class to a city council meeting, where the *Mission Specialists* present their songs and dances from Springfield. There is a large celebration as members of the entire city view the student performance of their dances and songs.

Example #2

Time: Maximum
Resources: Maximum

Ms. Enriquez's Science Class and Mr. Kim's Art Class, The Zabriskie School

The Zabriskie School is located in a rural community in America's Midwest. Students at the Zabriskie School are excited about using their brand-new computer lab to research and design their Mars community.

Reflect: Ms. Enriquez and Mr. Kim choose to have their classes work together as one *Project Team* so that each class member can learn about the other discipline. The classes get together and discuss what makes their community different—farming, raising livestock and crops, and the flat landscape.

Imagine: The students talk to their parents and grandparents and research the development of agriculture in their area. They also interview the nearby town's mayor and other civic leaders. They then use the Internet to learn about alternative crop management systems for arid climates like that on Mars. They study the art of American landscape painting and how it represents the wide open spaces in which their communities thrive.

Discover: The art class learns about 3-D modeling and takes field trips to galleries that feature space art and to other space-related locations, while the science class researches Mars using NASA's interactive Web materials, The Planetary Society's on-line Mars Rover, and other Internet resources. They hold a conference call with an artist who paints landscapes of other planets to understand how these landscapes differ from those they studied earlier. Taking advantage of their computer lab, the *Project Team* chats on-line with other *Project Teams* from across the country, each sharing their questions and answers. They also chat with astronauts on the Mars Millennium Project *Web site*.

Create: Once a week, the two classes meet and discuss what they have learned and what thoughts they have. At the end of the semester, the *Project Team* works together to build a 3-D model of the community and to write their one-page essay about how they integrated ideas from space art, American landscape painting, and their own history to design the look and feel of their community.

Share: After turning in their *Data Forms*, the *Project Team* holds an event for the whole school and all the parents where they present their creation. Mr. Enriquez's class also enters their Mars community in the county science fair and wins first prize.

Example #3

Time: Minimum
Resources: Minimum

The Library Club

The members of the Mount Hebron Library Club are very interested in the Mars Millennium Project. However, they meet for only an hour and a half once a week. Because the club has only five members, the group decides that they should all be part of one *Project Team*.

Reflect: The club studies what brings it together—the library. Why do all of its members come there? What do they like about it? The members talk to each other to find out the answers to these questions.

Imagine: After learning about each other and their priorities, club members decide to center their project around creating a newspaper for the new colony on Mars. Club members interview their parents and grandparents to learn about newspapers in history and what makes news. They also read old newspapers from the library's archives. Finally, they name their community project The Daily Planeteers.

Discover: Some members are given the job of talking to community members about what newspapers and magazines they like, what interests them and what matters most to the community. Others research the publishing process, interviewing their local newspaper's editor. All members watch a short documentary on the development of printing and read one book of their choice about Mars.

Create: After a month, the club meets and plans its Mars community. Based on their research, the club members decide to develop a mock-up of an on-line community newsletter with original content inspired by the experience of living on Mars. They write about how they decided what was news and how they chose to have an Internet newsletter rather than a print newspaper.

Share: After submitting a photograph of their first newsletter, the club contacts a local Internet service provider and gets it to publish its on-line newsletter. All members of the *Project Team* also tell their homeroom classes at school about what they have learned and encourage them to read the on-line newsletter.

Example #4

Time: Minimum
Resources: Maximum

Junior Explorers, Squadron 4747

The girls of Junior Explorers Squadron 4747 are ready to tackle the Mars Millennium Project. They spend most of their time learning about things like lifeguarding and orienteering, but they are able to devote an hour a week to the project for several months.

Reflect: Because the Squadron is made up of a dozen girls, the Squadron Leader decides that the Squadron should form two *Project Teams*. The Junior Explorers learn that a passion for physical fitness has brought them together.

Imagine: The *Mission Specialists* talk to their family members about physical fitness and community service through the generations. With this knowledge of physical fitness, each member of the *Project Team* imagines how they might want to keep physically fit and how they could compete in sports with each other on the planet Mars under different gravity conditions and with much less atmosphere. They also explore how modern dance and ballet might be adjusted to fit the new environment. They decide that their community should be called the "Jumping Jack Flats."

Discover: Each *Mission Specialist* selects a task; Explorers with more achievement medals pick first. One of the first girls to pick chooses how people would move in the low-gravity environment of Mars, while one of the last girls to pick has to find out how many gallons of water the very active community would need per day and how much space that would take up. Throughout the months, the girls research their topics on the Internet at the lab in the local library. They invite a doctor to talk about sports medicine and they go to the desert to study how heat affects sports and physical performance such as ballet. Using the *www.mars2030.net Web site*, the *Project Team* interacts with other *Project Teams* across the country.

Create: At every Squadron meeting, each girl discusses her project and makes assignments. Toward the end of the semester, the entire Squadron meets and the Explorers all tell what they have learned. Based on this, the Squadron Leader decides that they should write about how they will ensure physical fitness for the whole community and, using a 3-D modeling program they downloaded from the Internet, they design a Mars community exercise center.

Share: After they have submitted their materials to the Mars Millennium Project, the Squadron organizes an exhibition of their and other squadrons' Mars communities at their local YWCA. They also display their Mars community at their state and national conventions.

Resources: Reference Materials

Search, Discover, and Learn

The Mars Millennium Project and related student projects emphasize hands-on involvement and partnership building. Where possible, the activities recommended make use of inexpensive and easy-to-find resources. The resources listed on this worksheet represent only a small sampling of the materials available for learning environments. Use your imagination to help your *Project Teams* think about all the possibilities for the next century and where they might go for information.

Sponsor Web Resources:

Mars Millennium Project Web Site
http://www.mars2030.net

National Aeronautics and Space Administration Web Site
http://www.nasa.gov

Jet Propulsion Lab Photo Archive
http://www.jpl.nasa.gov/mars/

National Endowment for the Arts Web Site
http://arts.endow.gov/

U.S. Department of Education Web Site
http://www.ed.gov/

Getty ArtsEdNet
http://www.artsednet.getty.edu/

Sample Resource Books:

Discover Mars — Skurzynski, Gloria. Washington, D.C.: The National Geographic Society, 1998.

In the Stream of Stars: The Soviet/American Space Art Book — Edited by Hartman, William K., et al., New York: Workman Publishing, 1990.

Managing Martians: The Extraordinary Story of a Woman's Life Long Quest to Get to Mars — Shirley, Donna. New York: Broadway Books,1998.

Mars: Uncovering the Secrets of the Red Planet—Raeburn, Paul, and Golombek, Matt. Washington, D.C.: The National Geographic Society, 1998.

Mars and the Mind of Man — Bradbury, Ray; Clarke, Arthur C.; Murray, Bruce C.; and Sagan, Carl. New York: Harper and Row, 1973

Mission to Mars: An Astronaut's Vision of Our Future in Space — Collins, Michael. New York: Grove Wiedenfield, 1990.

Return of the Red Planet — Eric Burgess. New York: Columbia Press, 1990.

The Adventures of Sojourner: The Mission to Mars that Thrilled the World — Wunsch, Susi. New York: Miyaka Press, 1998.

The Case for Mars: The Plan to Settle the Red Planet and Why — Zubrin, Robert, and Wagner, Richard. New York: The Free Press, 1996.

The New Solar System — Beatty, J. Kelly; Chaikin, Andrew; and O'Leary, Brian. Cambridge, Mass.: Sky Publishing, 1990.

The National Endowment for the Humanities (*http://www.neh.gov*) provides many resources to help students explore what kind of government and social organizations they might want to consider as they create their Mars Colony. By accessing EDSITEment, an easily navigable portal Web site at (*http://edsitement.neh.gov*), teachers and students will find lesson plans and classroom activities on the United States Congress, the presidents, and the Supreme Court; challenges to democracy—during the Civil War and the Great Depression—and ideas embodied in myth and literature such as those found in the legend of King Arthur.

The Participation Guide is also available to download from the Mars Millennium Project Web site.

Resources: Video

Up Close and Personal: A Video About Artists, Scientists, and Astrounauts

To enhance the Mars Millennium Project, the National Endowment for the Arts (NEA) and its partners have interviewed artists and scientists across America who work together to create projects that stimulate imagination and draw interesting connections between the arts and sciences. This resource provides an inside glimpse into what inspires them and moves them to create some of our world's most beautiful and thought-provoking creations.

Among the topics presented in the video will be how scientific insights and discoveries can influence the creation and production of art, and how art is often influential in the design of livable structures.

Be sure to visit *www.mars2030.net* to find out how you can request your copy of this exciting and informative visual resource.

Get your *Mission Specialists* to THINK about the future.

Registration Information

Submitting Entries "MARS2030 Virtual Gallery"

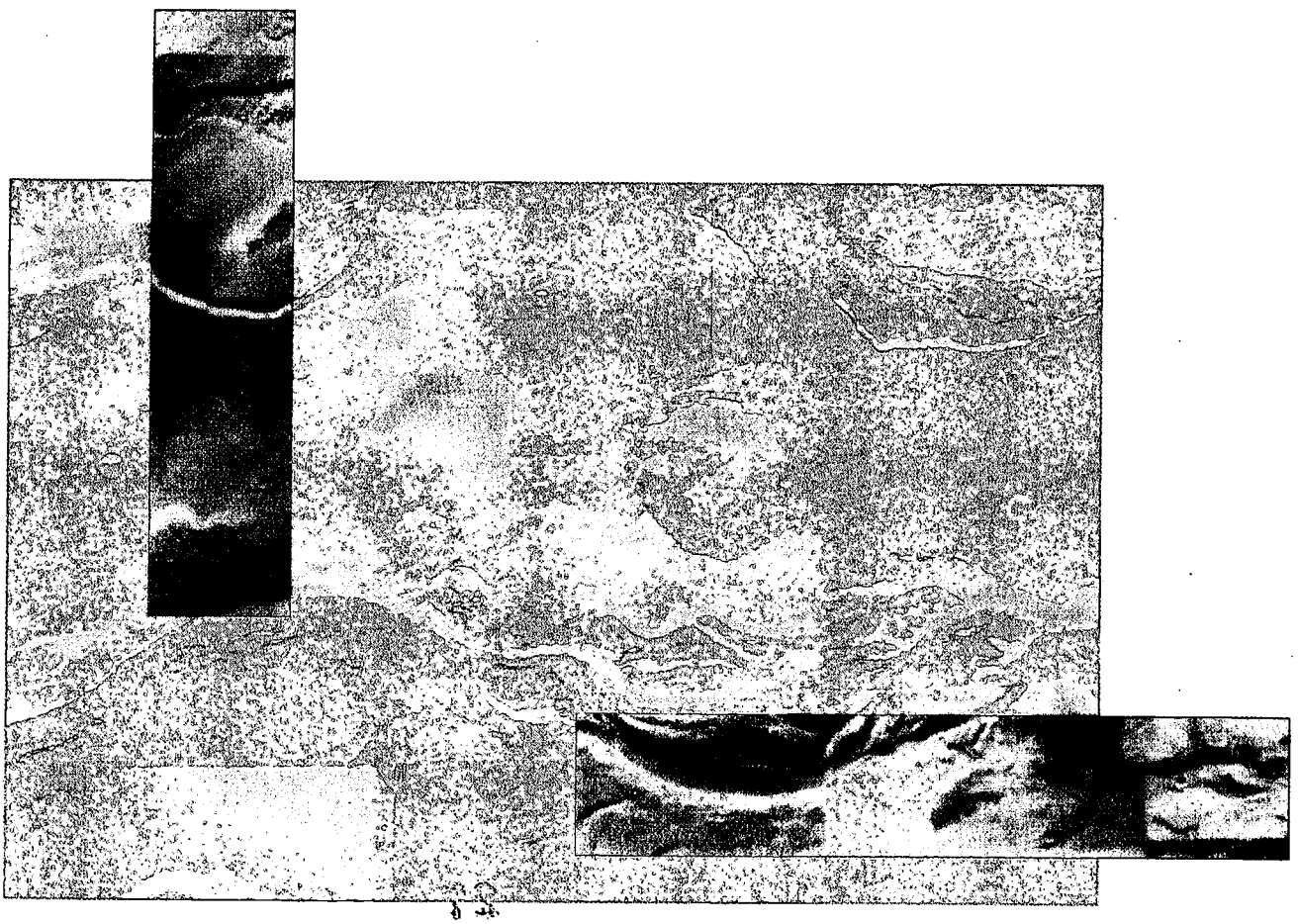
IMPORTANT!!!
JUNE 1, 2000-DEADLINE FOR PROJECT SUBMISSION

All *Project Team* entries can be submitted on-line at *http://www.mars2030.net*. Open the Web gateway homepage and click on the windowpane labeled "*Virtual Gallery*" and you will be guided through the registration process. All submissions must be entered on-line before June 1, 2000, to be eligible for inclusion in any exhibitions and culminating events. There are three easy steps to complete your registration successfully:

- Registration
- Project Description
- Photograph that can be submitted electronically

The Web gateway for *Mars2030* has been designed to allow you to share ideas with others while making the best use of what the Internet has to offer. The Web resource has been created for easy access and loaded with information to make efficient use of your time.

The following information will be requested on-line. Use the following worksheets to prepare for your on-line submission. Tear-out copies of these worksheets can be found at the end of this book.



Registration Information: Sample Worksheets

Virtual Gallery: Part 1
On-line Registration Information

Use this worksheet to prepare information for your on-line submission.

_____

Mission Name
(Use up to a total of 20 letters and numbers, including spaces. Please do not use symbols or punctuation.)

_____

Project Team Supervisor's Name

_____

School or Organization

_____

Grade Level

_____

Address

_____

City *State* *Zip*

_____

Phone *Fax*

_____

E-mail

Virtual Gallery: Part 2

Project Description

Use this worksheet to prepare information for your on-line submission.

Describe Your Work
To better understand how you imagined your community, *Mission Control* would like to know about the issues and challenges your *Project Team* confronted while integrating art, science, and culture in designing your Mars community. For the project summary section, write a description of your *Project Team's* community: what artistic, scientific, and technical challenges you faced in creating it; what you learned about your own community; and what you hope for the future. *Project Team* members should collaborate on the summary with discussion and debate to reach conclusions that represent the group's project. You may want to designate one *Mission Specialist* to record these ideas and write the project summary.

Limit your submission for the project summary to 500 words or less.

Answer the following questions, as well as any others that may have come up as you completed your project:

- How did you make your community livable?
- How did you make it an inviting place to live and work?
- How did you organize and manage your community?
- What did it mean to be a citizen in your community?
- What major artistic inspirations did you have?
- What major technical and scientific factors did you take into account?
- What did you learn about the community around you?
- What do you want the community of the future to be like?

Once completed, use the space provided on the on-line submission form to enter your ideas.

Virtual Gallery: Part 3

Photograph of Your Project

Use this worksheet to prepare information for your on-line submission.

Exhibit Your Work
The *Mars2030 Virtual Gallery* is where ideas and creations of *Mission Specialists* and *Project Teams* will come together in the on-line environment.

Project Teams will submit their registration information along with their ideas and visual representation.

Mission Control is interested in understanding the design and appearance of your *Mars2030* community. Create a visual representation of the entire community designed by your *Project Team,* or any artistic or scientific element or aspect of your new community.

For example, this representation might be (but is not limited to):
- a constructed model of the *Mars2030* community;
- a computer generated two or three dimensional design;
- a work of art—two-dimensional drawing, painting or other artwork; a three-dimensional sculpture, diorama, or other artistic visual representation;
- performance art—a dance, theatrical presentation, opera, orchestral, or choral presentation; or
- a visual representation of an equation, science fair project, theory.

Remember, this project is full of variety and answers to questions in many forms employing the arts, sciences, and technology. It can show (but is not limited to) your entire community, a small portion or a component of your community, or it can be something a member of your community might create.

To submit your project to the *Virtual Gallery*, please photograph your visual representation, using slide (35mm transparency) film or digital camera to create your community's homepage, then go to *www.mars2030.net*, click *"Virtual Gallery,"* and follow the directions shown there. Submitting a link to a *Web site* containing your *Data Form* does not constitute submission of the *Data Form.*

Below, describe in a few sentences what this slide shows.

Definitions

Project Key Words

Cooperating Organizations:
More than 100 national professional and service non-profit organizations representing communities from the arts, sciences, humanities, technology, and education supporting the project.

Contributing Partners:
Private sector businesses and corporations who have lent their support for the project through contributions or in-kind services.

Data Forms:
In this booklet, the *Registration Information Sheets* featuring brief exercises that must be completed as part of the Mars Millennium Project.

Deadlines:
To be eligible for inclusion in the *Virtual Gallery,* and to participate in *Project Extensions,* all of your submissions must be registered with *Mission Control* before June 1, 2000.

Mars2030:
The Mars Millennium Project's nickname.

Mission Control:
Mission Control is the headquarters and clearinghouse for all Mars Millennium Project activity. Technicians at *Mission Control* can provide helpful support and information and point you in the right direction for information and resources.

Mission Guide:
In this booklet, step-by-step instructions for completing the project.

Mission Name:
Each *Project Team's* community will have a specific, one-of-a-kind *Mission Name* that you create. This name can have a maximum of 20 letters and numbers including spaces; please do not use symbols or punctuation. Your *Mission Name* will identify your *Project Team* and Mars community and is your way of finding your project in the *Virtual Gallery.*

Mission Specialist:
All individuals, whether part of a class, a club, a library, a museum, a community organization, or any type of group involved in the Mars Millennium Project, are *Mission Specialists.*

Participation Guide:
This booklet is called the *Participation Guide.* It contains information about the project and about art, science, and the planet Mars. It contains all the information you need to complete the project.

Project Extensions:
A number of national organizations and corporations have designed complementary sweepstakes and contests around the Mars Millennium Project.

Project Team:
A group of *Mission Specialists* forms a *Project Team.* You can organize a *Project Team* by dividing your class, club, or organization into several *Project Teams,* or you can form your entire class, club, or organization into a single *Project Team.* Each Mars community is designed by a single *Project Team,* and each *Project Team* designs only one community.

Sponsors:
The original creators of the Mars Millennium Project, including the U.S. Department of Education, the National Aeronautics and Space Administration, the National Endowment for the Arts, and the J. Paul Getty Trust, in partnership with The White House Millennium Council.

Activities and Resources:
One section of the *Participation Guide* that contains information and questions designed to help you learn about Earth, Mars, and your community.

Supervisor:
This can be a teacher or group leader who is responsible for managing a *Project Team.* The role of the team *Supervisor* is to provide support, resources, and guidance to the *Mission Specialists* comprising each *Project Team.* When the mission is complete, the *Supervisor* will submit the official registration form with a team name to *Mission Control* to be considered for recognition in *Mars2030* culminating events.

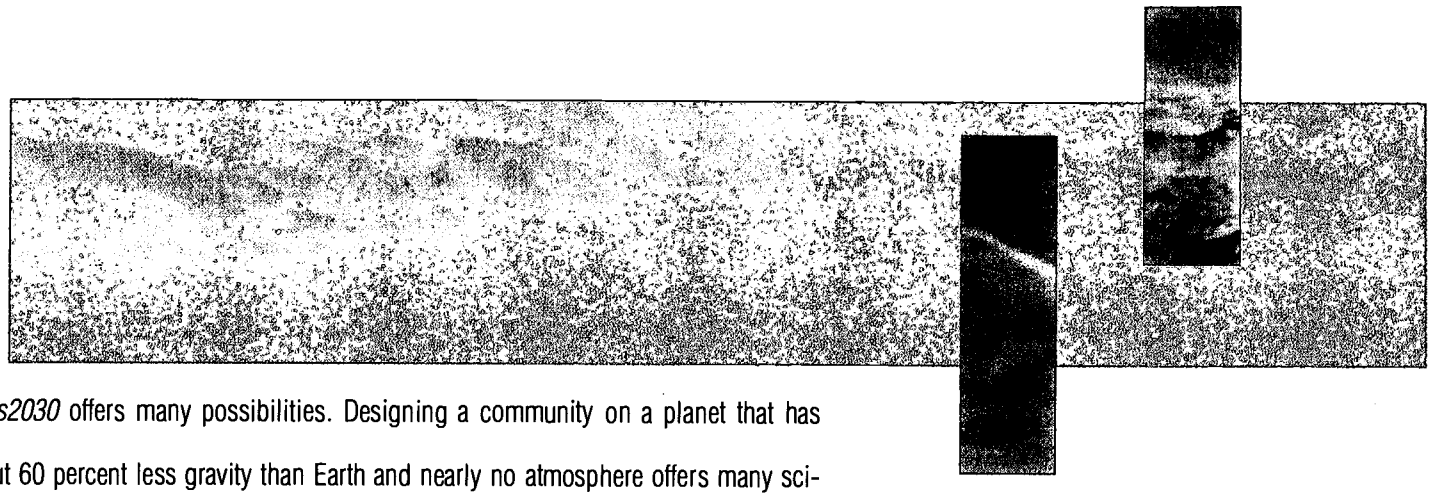
Definitions

Web Key Words

- *Web Site:* An on-line resource where you can find out about the project; learn from scientists, artists, and astronauts; collaborate with other *Project Teams*; access resources; find dedicated sites focusing on the planet Mars; and much more! The Mars Millennium Project *Web site* can be found at *www.mars2030.net.* Look through the four windowpanes on the Web homepage to find the following:
- *Virtual Gallery:* An on-line site for submission of completed projects. The *Virtual Gallery* houses visual representations of communities on Mars and includes project summaries of ideas describing the challenges and successes faced by participants. A microchip embedded with information from the gallery will be sent to Mars on a future NASA mission.
- *Artists, Scientists, and Astronauts:* A special place hosted by The Planetary Society where you can learn from art, science and space experts and acquire information about what inspires people to imagine and create.
- *Mars:* Reliable, authentic information about the planet Mars is available in this area by NASA. Visit this to receive remarkable images from space as well as scientific facts and data.
- *Chat and Interact:* It is through this windowpane that you will meet a community of others participating in the project. Hosted by *USA TODAY* through Copernicus Interactive and AOL, this is a virtual forum for those who wish to share their ideas and pose questions to other participants.

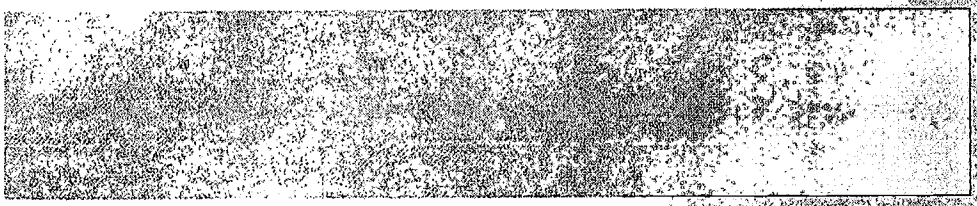
Building a Team:
Here are some ideas to keep in mind while building your *Project Team:*

- Teams work as groups, not as individuals.
- Even though teams are usually thought of as having leaders, yours does not have to. Everyone can work together as equals.
- *Mission Specialists* might want to decide who does what in the group, rather than the teacher or other adult in a position of authority.
- Teams work better when everyone communicates, so let everyone be heard!
- If certain people on the *Project Team* have knowledge about certain areas of the project already, you might want to have them work in the area they know best. On the other hand, they could work in an area they do not know much about and expand their knowledge that way.

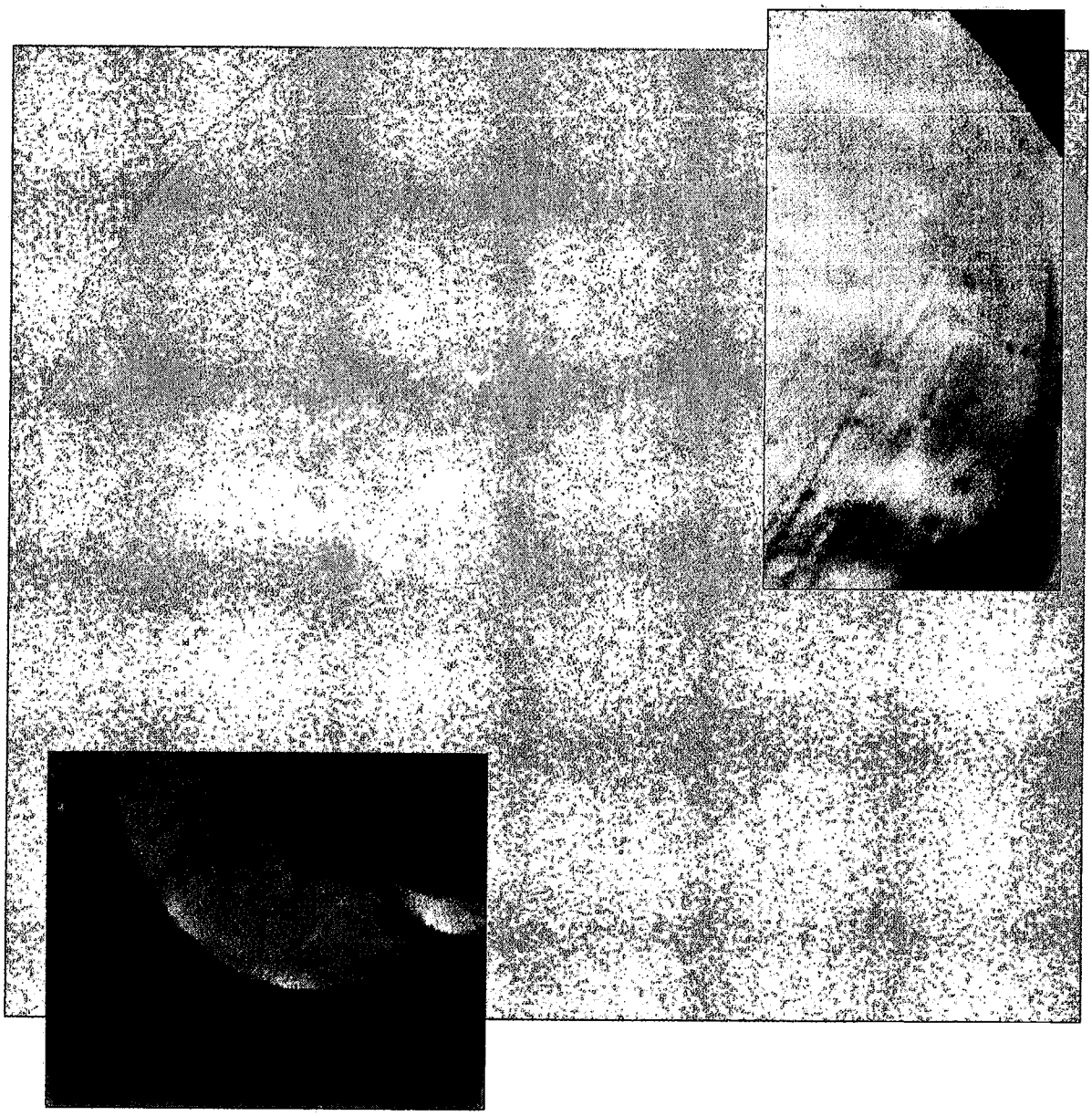


Mars2030 offers many possibilities. Designing a community on a planet that has about 60 percent less gravity than Earth and nearly no atmosphere offers many scientific, artistic, and technological learning opportunities. What would the design of the living space or home base be like to be safe for human habitation? How would water be provided and recycled? Imagine how a dance or sport might change: Do basketball hoops stay the same height? Can we use Earth golf balls? How high might a dancer be able to leap? Remember, Mars' gravity is less (making a person weigh less), but mass and inertia remain the same. Or consider the atmosphere: Would the sound from horns on intra-community rovers travel far enough, or would they be too loud? Would lights need to be more or less powerful? Where would you locate your community on Mars and why? What would the town mural look like or town song sound like on Mars? On Earth? Answering a simple question such as, "How much trash will be created and need to be treated?" leads to a string of math estimates as well as possible solutions to organizing civic life.

Interested in more? Check out projects from *Contributing Partners* and *Cooperating Organizations* that are being designed in conjunction with the Mars Millennium Project. They can be found in your *Project Team Supervisor's* resource kit or on the Mars Millennium Project *Web site www.mars2030.net.*



Materials Prepared by the National Endowment for the Arts and the National Aeronautics and Space Administration



Question 1: What is a community?

A. In what ways do the arts help to identify a community?

Topics to Explore

- Role of the arts and artists in past communities, societies, and civilizations
- Role of the arts and artists in my community today
- Role of the arts in future communities, including those in space
- Family arts traditions

Possible Activities

- Study past civilizations' uses of the arts to record aspects of different communities through such art forms as pottery, storytelling, cave paintings, songs, and dances.
- Consider the works and views of writers and artists who are concerned with the future, and particularly how communities in space might look and function.
- Identify and discuss particular contributions or roles that musicians, painters, sculptors, actors, and other artists play in your community.
- Have students talk with parents, grandparents, and other family members about ways in which artistic traditions have been a part of their family's heritage and how these traditions have been linked to the community.

http://www.symphony.org
American Symphony Orchestra League (ASOL)—Listing by state of member organizations and Web links. Web site for students (www.playmusic.org) provides information about the various sections and instruments of the orchestra plus electronic correspondence with musicians and other interested students.

http://www.ciconline.com
Cable in the Classroom—Public service of 38 national cable companies and more than 8,500 local cable companies. Information on contacting local cable companies, advance program information and access to a monthly magazine. Teacher support materials include "Thinking Outside the Box," which features contemporary artists discussing creative thinking, and "Men in Space: From Goddard to Armstrong," an A&E Classroom documentary.

Murmurs of Earth: The Voyager Interstellar Record, Sagan, Carl et al. (1978). Ballantine Publishing. This book takes a behind-the-scenes look at the background of the Voyager mission out of our solar system, focusing on the artwork and music carried aboard the spacecraft to represent Earth's culture.

B. How do the arts make my community different from neighboring communities? Communities in other states or regions? In other countries?

Topics to Explore

- Cultural tourism and other ways that the arts are important to a community's economy
- Arts attendance, participation, and patronage
- How arts events and activities are conceived and carried out

Possible Activities

- Research the artists, arts institutions, organizations, or resources for which your community is particularly known.
- Contact your municipal government and ask if there is an organization or person responsible for the arts.
- Ask your local tourism or visitors bureau what arts resources or events attract people both from within and outside of your community.
- Design a travel poster for your town, city, or county highlighting its characteristics and amenities in the arts.

http://www.artsusa.org
Americans for the Arts—Maintains a clearinghouse on the arts and culture in the United States. Topics include attitudes toward, and participation in, the arts; community development and the arts; and economics of the arts including the impact of the arts on communities, the arts industry, and tourism. Publications and resources concerning community cultural planning and related topics are available to order.

American Participation in Opera and Musical Theater 1992, Toni Maya Cherbo and Monnie Peters (1995). This report analyzes participation in opera and musical theater/operetta and compares it with participation 10 years earlier. ISBN 0929765389. Seven Locks Press, Santa Ana, CA.

Turning On & Tuning In: Media Participation in the Arts, Charles M. Gray (1995). ISBN 0929765397. Results of a study showing how Americans participate in the arts via television, radio, and sound recordings. Seven Locks Press, Santa Ana, CA.

American Participation in Theater, AMS Planning and Research Corp. (1996). ISBN 092976546X. This study examines the characteristics of the audience for stage plays as well as the dynamic forces that shape theater participation. The evolving nature of theater is also discussed, including changes in production and artistic focus. Seven Locks Press, Santa Ana, CA.

1997 Survey of Public Participation in the Arts: Summary Report, National Endowment for the Arts (1999). This report describes the results of the 1997 Survey of Public Participation in the Arts (SPPA). In addition to attendance at arts activities and participation through broadcast and recorded media, it covers geographic and demographic differences in participation, arts socialization, music preferences, and other leisure activities. Available on-line from the Arts Endowment's Web site (http://www.arts.endow.gov).

C. How do the arts help people from various parts of my community communicate with and understand one another?

Topics to Explore

- Arts as communication and conveyance of thoughts, ideas, and feelings
- Passing on or sharing of cultural traditions through the arts
- Multicultural awareness and understanding

Possible Activities

- Explore the ways in which various ethnic communities express their cultural values and traditions through festivals, ceremonies, celebrations, and other traditions.

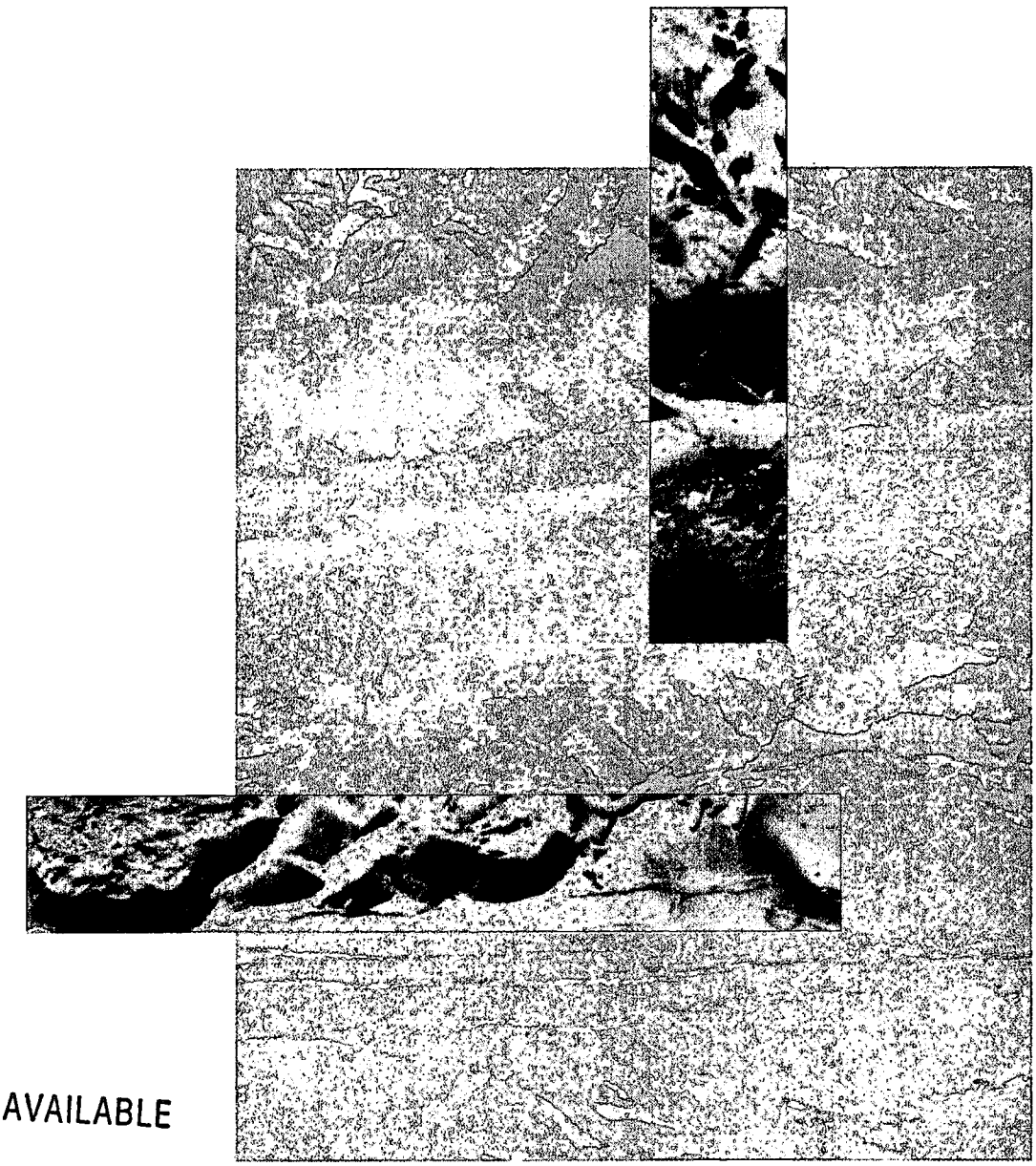
http://www.carts.org
Cultural Arts Resources for Teachers & Students (CARTS)—Sponsored by CityLore and the National Task Force on Folk Arts & Education. Provides access to *The Culture Catalog* of print and multimedia resources plus regional resources for teachers.

Architecture and the American Dream, Craig Whitaker (1998). ISBN 0609803085. An award-winning architect makes a case that our cities and houses reflect our American culture. An interesting and thought-provoking look at why and what we build as a society, with more than 400 illustrations. Crown Publishing Group.

Culture Builds Community: A Guide to Partnership Building and Putting Culture to Work on Social Issues, Partners for Livable Communities (1995). ISBN 0941182215. This guide can be used by teachers and high school students to better understand the cultural influences in their communities. Text and worksheets focus on such areas as defining community, art, and culture; youth development; economic development; and multiculturalism. Partners for Livable Communities, Washington, D.C.

Alignment With National Standards for Arts Education

	1	2	3	4	5	6	7	8	9
Dance			X		X		X		
Music							X	X	X
Theater							X	X	
Visual Arts			X	X	X	X			



Question 2: How would your community be different on Mars?

A. What types of arts events might actively engage all 100 persons in the Mars community?

Topics to Explore

- Relationship of audience to artist
- People who participate in the arts
- Design of art spaces such as museums and galleries, theaters, and music halls.

Possible Activities

- Attend arts events in visual art or performing arts venues in your community that accommodate only 100 people and observe how people interact.
- Talk with people in your community who are actively involved in making art (including professional and folk or traditional artists or musicians, and members of community theaters or orchestras) about why they are engaged in the arts and why they would want to have that same kind of engagement on Mars.
- Investigate the architectural and design principles and considerations behind the creation and programming of arts facilities.

http://www.aiaonline.com
American Institute of Architects (AIA)—Includes a "Find an Architect in Your Area" database plus publications and other resources helpful to teachers.

http://www.chamber-music.org
Chamber Music America—Provides contact information to connect local chamber music enthusiasts with professional and amateur musicians, composers, critics, and administrators.

http://www.artswire.org/Artswire/danceusa
DanceUSA—Includes lists of member dance companies and dance presenters nationwide plus a recent study of dance audiences.

http://www.operaam.org
OPERA America—Lists member companies and links to education programs of companies.

http://www.tcg.org
Theater Communications Group—National organization for the American theater includes listings of more than 300 nonprofit theaters.

Discover America's Favorite Architects, Patricia Brown Glenn, Joe Stites (Illustrator), (1996). ISBN 0471143545. Ten preeminent American architects—from Thomas Jefferson to I.M. Pei—are brought to life for young readers with text and illustrations that introduce significant works by each of the architects. Among the projects depicted are residences, banks, train stations, museums, outdoor plazas, and public parks. John Wiley & Sons.

Destination Mars: In Art, Myth, and Science, Jay Barbree, Martin Caidin, Susan Wright (Contributor) (1997). ISBN 0670860204. A blend of popular scientific information on Mars and how it has been treated in mythology and popular culture. The book has numerous illustrations and is probably the most comprehensive collection of Mars artwork for teachers and students.

B. How would you use technologies—those we have today and those you can envision as possible in 2030—to involve members of the Mars community in the arts? Which technologies would increase their involvement as makers of art and which would increase audience participation?

Topics to Explore

- Communications technologies, both current and under development by scientists
- Ethical considerations of technology replacing direct interaction among people
- Media in our lives and media literacy as needed knowledge and skill

Possible Activities

- Create a typical day's or week's program schedule for a public television or radio station in the Mars community.
- Develop a script for a documentary about the first week, month, or year of the Mars community.
- List the various kinds of communications technologies we use today; discuss how useful they might be in a community on Mars; and develop ideas for one or more new uses of technology that would help create and communicate using the arts.

Literacy in a Digital World: Teaching and Learning in the Age of Information, Kathleen Tyner (1998). ISBN 0805822267. This book explores the juncture of the educational technology and the media education movements to help realize a new way to view teaching and learning in the age of multiple literacies. Lawrence Erlbaum Associates, Inc.

Learning with Technology: The ASCD Yearbook. Chris Dede, Editor (1998). ISBN 0871202980. Based on innovative school programs today, technology programmers, developers and researchers focus on using new media to achieve 21st century educational objectives through global partnerships for education. Association for Supervision and Curriculum Development (ASCD).

Educational Leadership: Integrating Technology Into the Curriculum. Volume 56, No. 5. Margaret M. Sherer, Editor. This issue of the ASCD monthly journal explores educators' desire for "the balance between the humanistic education we value and the technology that can make kids lifelong learners." Association of Supervision and Curriculum Development.

C. What proportion of the visual and design arts found in the Mars community should be brought from the Earth community? What proportion should be created in the Mars community?

Topics to Explore

- Fashion and furniture design
- Found and recycled objects as art
- Personal aesthetic values and tastes

Possible Activities

- Adapt your multi-season wardrobe to the seasons, atmosphere, and temperatures of Mars.
- Visit the local recycling center to determine what types of recycled products your community on Mars might produce and ways in which the products could be used as art.
- Use resources in your community or on the Internet to study the properties of clothing materials and home furnishings.
- Give individual students or small groups "art dollars" with which to purchase a limited number of art objects to take on the Mars journey. Have them discuss the objects' aesthetics as well as practical reasons for the choices.

http://www.nga.gov
National Gallery of Art—Maintains both a directory of education resources (www.nga/gov/resources/derdesc.htm) and a national directory of teacher education programs and resources in art museums nationwide (www.nga.gov/resources/tpmain.htm).

BuckyWorks: Buckminster Fuller's Ideas Today, James T. Baldwin (1996). ISBN 0 47112953 4. This retrospective on the discoveries and inventions of architect, mathematician, engineer, inventor, and educator Buckminster Fuller provides inspiration for considering alternative ways to approach the future of life and work. The book contains more than 200 photographs, drawings, and plans that demonstrate how Fuller nurtured his ideas from initial sketches to final product.

The Snows of Olympus: A Garden on Mars, Arthur Charles Clarke (1995). ISBN 0393039110. Through the use of computer-generated images, a terraformed Mars is depicted in stages in which it might occur. The author discusses the changes that will occur on the Mars surface as water and vegetation progress as a result of human habitation. W.W. Norton and Company.

D. In what ways would the performing arts (music, dance, theater, opera, musical theater) be different for both the artists and audiences on Mars?

Topics to Explore
- Lighting and sound design
- Architecture and design properties of performing arts facilities
- Physical space needs for various types of music, dance, theater, and opera

Possible Activities
- Visit local architects; lighting, scene, and sound designers; and technical directors in your community and discuss the challenges they would find most interesting about designing performing arts spaces and works for dance, music, theater, and opera on Mars.

http://www.usitt.org
United States Institute for Theatre Technology (USITT)—Association of design, production, and technology professionals in the performing arts and entertainment industry. Information on regional sections of USITT's membership, student chapters of USITT, and listing of available publications about theater design and production.

http://www.aiaonline.com
American Institute of Architects (AIA)—Includes a "Find an Architect in Your Area" database plus publications and other resources helpful to teachers.

The Changing Faces of Tradition: A Report on the Folk and Traditional Arts in the U.S., National Endowment for the Arts (1996). This report combines information from two surveys of folk and traditional arts organizations with case studies to describe the breadth and depth of folk and traditional arts activity in the U.S. and how it is increasing in both the variety of cultural worlds involved and the level of activity. Available from the NEA at http://www.arts.endow.gov/pub/general.html.

Alignment With National Standards for Arts Education

	1	2	3	4	5	6	7	8	9
Dance	X	X	X	X		X	X		
Music				X		X	X		X
Theater	X		X	X	X	X	X	X	
Visual Arts	X	X	X	X	X	X			

Question 3: What makes life in your community meaningful?

A. What would your community be like if there were no art or arts activities? What would be different? How would it affect you? Your parents? Others in the community?

Topics to Explore

- Artistic expression and communications
- Avocations and use of leisure time
- Careers in the arts
- Ways the arts bring business and resources to the community

Possible Activities

- Find out what arts or crafts activities your family or community supports and why they are important to them.
- Devise arts activities for the nine-month-long trip that the first Earthlings going to Mars could take with them on their space voyage.
- Survey the local paper for one to two weeks and clip and discuss articles about arts events that you consider important to your community.
- Talk with the arts critic(s) of your local newspaper, radio, or television station about what arts events have an impact on the quality of your community.
- Interview citizens to determine what role they think the arts have in your community.

http://www.artsusa.org/clearinghouse
Americans for the Arts—Clearinghouse of information on topics including economics of the arts, artist demographics and needs, and American attitudes about participation in the arts.

Step Outside: Community-Based Art Education, Peter London (1994). ISBN 0435087940. Designed for both the art specialist and the classroom teacher, *Step Outside* contains exciting ideas for children's art learning grounded in their lives and in the community. With a blend of text and illustration, essay and example, the book outlines the necessary components of a community-based art program, provides steps to create such a program, and offers a list of 80 "authentic art experiences in which children encounter the real world of their community." Heineman.

Careers in Art: An Illustrated Guide (Second Edition), Gerald Brommer and Joseph Gatto (1998). ISBN 0871923777. This revised edition covers dozens of long-standing and new careers in the art and design fields. Davis Publications.

B. How are decisions made about what exhibits or performances occur at the local museum, performing arts center, or theater? Who makes these decisions and what criteria do they use?

Topics to Explore

- Artistic perspectives and points of view
- Art as a reflection of society
- Use of the arts to understand history and civilizations

Possible Activities

- Interview the artistic directors of theater or dance companies, orchestras, or other arts organizations to find out how they interpret the values and interests of your community through their artistic selections.
- Visit Web sites of museums and arts centers from across the country to discover the views and thoughts of artistic directors, curators, and others involved in producing and presenting the arts.

http://www.aam-us.org
American Association of Museums—On-line bookstore for both members and non-members includes materials on a range of museum and visual art topics including exhibit planning and collections/conservation.

http://www.citylore.org/egi-local/shop/
The Culture Catalog—Nonprofit, on-line service sponsored by CityLore and the National Task Force on Folk Arts in Education. Topics of resources available to educators and students include Urban Life and Culture, Multicultural Resources, and American History.

Exhibiting Dilemmas: Issues of Representation at the Smithsonian, Amy Henderson and Adrienne L. Kaepler, Editors (1996). ISBN 1560986905. Twelve essays on diverse holdings of the Smithsonian Institution—from the Hope Diamond to Zuni wood carvings—explore the range of social, political, and ethical questions curators must confront in developing exhibitions. The book provides insight as to how Smithsonian exhibits can spark the emotions and memories of visitors to America's national museum. Smithsonian Institution Press.

C. What role do the arts play in the environment?

Topics to Explore
- Landscape architecture
- Horticulture
- Environmental architecture and design

Possible Activities
- Take a tour of your town or city with a local preservation expert, architect, or other person well-versed in the architecture and the built environment to find out about significant buildings or places (public gardens, parks) in your community.
- Study the works of contemporary environmental artists to discover how they use the natural landscape to convey ideas and themes about our relationships with Earth.
- Study the work of architect Frank Lloyd Wright to see how he and other architects blend the built with the natural environments.
- Choose a place in your home, classroom, or community. Decide what kind of art would fit there and why. Consider implementing those ideas.

Walk Around the Block: Using Our Communities in the Present to Learn About the Past and Plan for the Future, Ginny Graves (1992). ISBN 0963203304. A self-discovery workbook for teachers and students in which students use their homes, neighborhoods, and cities to understand architectural design, city planning, preservations, geography, science, and art. Students keep a personalized journal of their investigations of their cities. City for Understanding the Built Environment.

Structures: The Way Things Are Built, Nigel Hawkes (1993). ISBN 0020005105. Human-created wonders of the world—from buildings, to bridges, to monuments—are explored from idea to design to construction through an informative text accompanied by diagrams, cutaway drawings, and photographs of the structures. Macmillian General Reference.

D. What role do the arts play in activities that celebrate either local, state, or national history, or your family or community's traditions and heritage?

Topics to Explore
- Role of the arts in commemorative events
- Commissioning of works of art

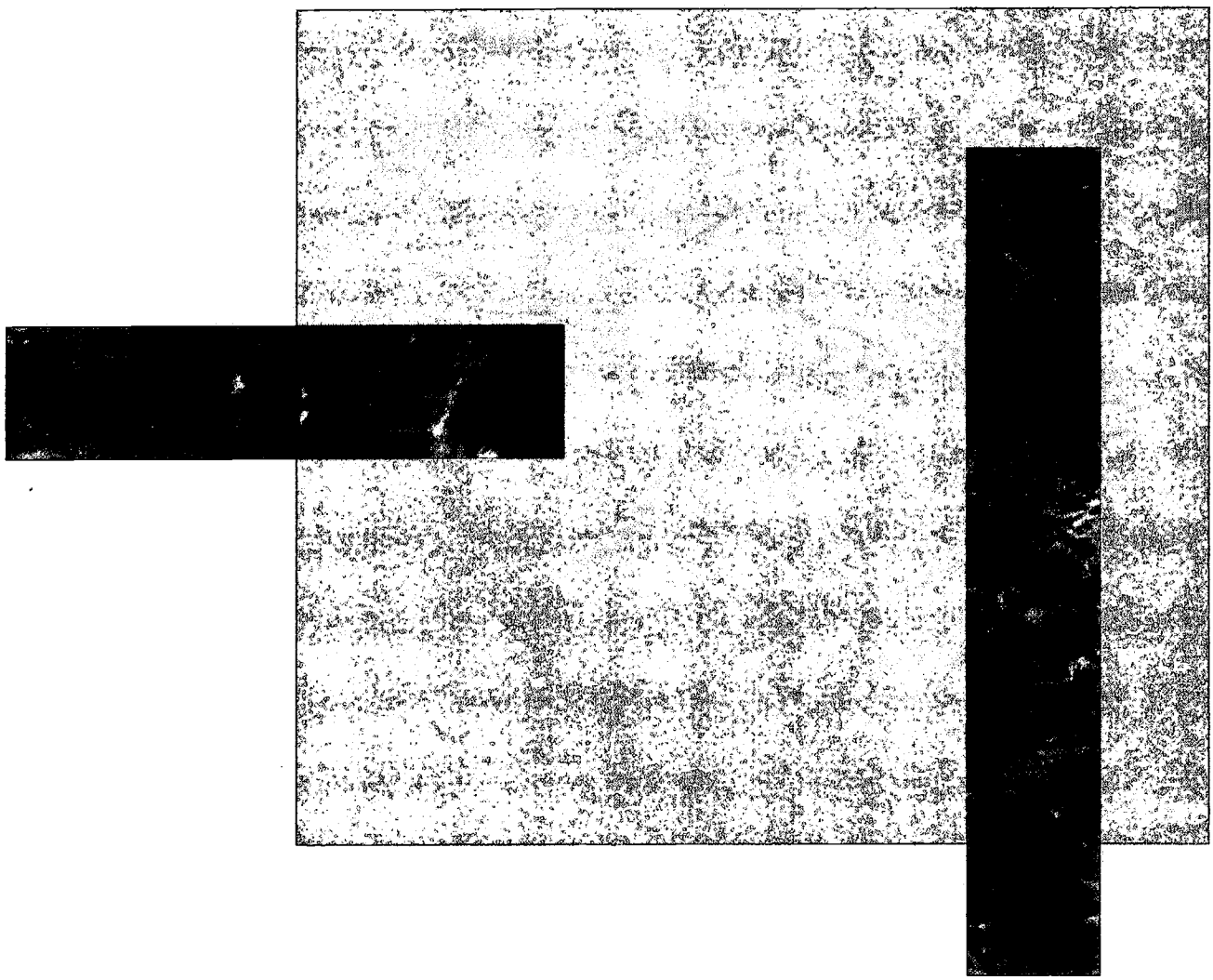
Possible Activities

- Determine a special occasion that would be celebrated on Mars and commission a musical score or song, or create a mural or other public art work to recognize it.
- Consider how you would celebrate American holidays in the Mars community.

Incredible Constructions and the People Who Built Them, Mel Boring, Sharon Farricker (illustrator) (1987). ISBN 0802765602. Describes the building of 10 constructions—from the Mesa Verde cliff dwellings and the Washington Monument to the Mount Rushmore carvings. In each case, the focus is on how ingenuity and dedication overcame warnings of "it can't be done." Walker Publishing.

Alignment With National Standards for Arts Education

	1	2	3	4	5	6	7	8	9
Dance	X		X	X	X	X	X		
Music				X		X	X	X	X
Theater	X				X	X	X	X	
Visual Arts	X	X	X	X	X	X			



Question 4: How would you create and represent your Mars community?

A. What aspect(s) of establishing a habitat on Mars most interests your students? Your school's teaching staff? Your school community?

Topics to Explore

- Surveying and interviewing
- Group consensus and decision-making
- Allocation of resources
- Advertising and promotion

Possible Activities

- Visit your local arts council or commission to determine what artists and arts organizations can be contacted for help with and involvement in your project.
- Survey parents about their knowledge, skills, and interests in the project and secure their involvement in "brainstorming" sessions with teachers, students, parents, and interested community members.
- Ask local reporters and editors to write articles about your plans for the Mars project and use the coverage to gather community ideas for and interest in the project.
- Design a promotional display for your project and place it in the school lobby, at a local mall, local government or office building to attract interest and solicit input and ideas.

http://www.naco.org
This site provides various resources and information on counties and their governance systems including model programs and a code of ethics.

CITY: A Story of Roman Planning and Construction, David Macaulay (1974). ISBN 0395349222. This book includes impressively detailed drawings and clear descriptive text that shows how superbly the Romans built new and exciting yet functional cities for the people who were to inhabit them. Houghton Mifflin Company.

B. What arts resources in your school and community best lend themselves to creating either a total Mars community or some aspect of that community? How can you use the Mars2030 Virtual Gallery to represent your project?

Topics to Explore

- Project planning
- Computer-assisted design
- Advertising and marketing
- Allocation of resources

Possible Activities

- Ask museums, galleries, performing arts centers, and other arts facilities in your community to include information about your plans in their newsletters, playbills, and programs. Design these ads or notices to include lists of artistic expertise and resources you need.
- Develop a performance—theater, dance, music, musical theater, or opera—that conveys your hopes and expectations for a community on Mars.
- Create a partnership with students and teachers in other schools in your community or in other states so they can share their ideas about the Mars community.
- Visit local architects to discover how computers are used to develop blueprints and models of spaces and buildings.

Alignment With National Standards for Arts Education

	1	2	3	4	5	6	7	8	9
Dance	X	X	X				X		
Music	X	X		X	X	X	X	X	
Theater	X	X	X	X	X	X	X		
Visual Arts	X	X	X	X	X	X			

Question 5: How can you begin today to improve your community?

A. What qualities or aspects of the arts as you have envisioned them in your Mars community are possible to achieve in your community in the next year? In the next five years? By 2030?

Topics to Explore
- Community planning for the arts
- Support for and participation in the arts

Possible Activities
- Meet with your mayor or other local government leaders to talk about what is important in a community and share the ideas and priorities you have developed from planning a community on Mars.
- Visit with local city or county planners to discuss how they make decisions about residential, commercial, and industrial development in your community.
- Find out how the arts are supported in your town or state. Compare it to other towns and states.

http://www.nlc.org
National League of Cities—This site is a resource for local government officials that will help you access the latest issues affecting policy makers and how policy is developed.

http://www.planning.org/info/infoguid.html
American Planning Association—Definitions and other information about land use planning. Electronic brochures include: "Ten Things You Can Do Right Now to Improve Your Community," "Business Improvement Districts and Urban Entertainment and Cultural Centers" and "What Is Planning?"

B. Who needs to consider your ideas for the arts in the community? How can you effectively share your ideas with them?

Topics to Explore
- Communications and public relations

Possible Activities
- Ask the mayor if you can display your Mars project at the town hall, and have students speak to the city or county council about what they learned about Mars and their own community.

http://www.usmayors.org
U.S. Conference of Mayors—This site allows you to identify mayors across the nation and lists the latest new projects and best practices.

Alignment With National Standards for Arts Education

	1	2	3	4	5	6	7	8	9
Dance			X	X		X	X		
Music						X	X	X	X
Theater						X	X	X	
Visual Arts		X	X	X	X	X			

For all five questions, here are several resources that should be referenced more generally:

Strategies for Teaching High School General Music, Keith P. Thompson and Gloria J. Kiester, Editors (1997). ISBN 1565450854. This resource is keyed to standards 1 through 9 of the national music standards and includes sample lesson plans. MENC: National Association for Music Education. (http://www.menc.org)

National Standards for Arts Education, Consortium of National Arts Education Associations, (1994). ISBN 1565450361. MENC: National Association for Music Education, 1806 Robert Fulton Drive, Reston, VA 22091.

Adaptations of the National Visual Arts Standards, Larry Peeno, Editor (1995). ISBN 0937652911. This resource includes examples of state departments of education, state art education associations and district models of adaptations of the national visual arts standards. National Art Education Association. (http://www.naea-reston.org)

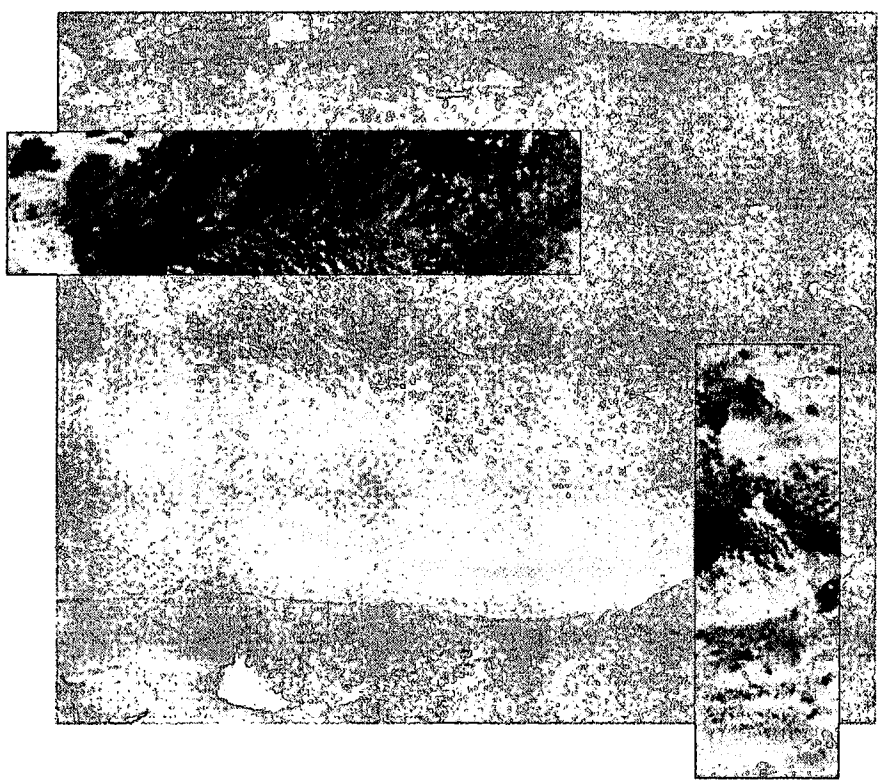
Available from ASCD (http://www.ascd.org):

Interdisciplinary Curriculum: Design and Implementation
Heidi Hayes Jacobs, Editor.
Available from the Association for Supervision and Curriculum Development.

Design as a Catalyst for Learning
Meredith Davis, Peter Hawley, Bernard McMullen, and Gertrude Spilka
Available from the Association for Supervision and Curriculum Development.

Mapping the Big Picture: Integrating Curriculum and Assessment K-12
Heidi Hayes Jacobs
Available from the Association for Supervision and Curriculum Development.

Planning Integrated Units: A Concept-Based Approach
Available from the Association for Supervision and Curriculum Development.



Mars Millennium Factoids

Mars Millennium Project NEA Factoids

As students, teachers, and others consider what a habitat on Mars would mean for the arts, several considerations are important. First among these is the nexus of science and aesthetics—what principles of physics, chemistry, geology, and other natural and physical sciences play integral roles in how we respond to, perform, and create art. While we take many of these principles, such as the vibrations that make up musical pitch and tone, for granted here on Earth, the atmosphere, gravity, and other factors on Mars make for challenging adaptations of music-making and listening.

Another dimension involves the social and environmental considerations we should not overlook as we conceive of arts activities for the Mars habitat. For instance, we can consider the difference that the Mars atmosphere and relationship to the Sun will have on a public sculpture like Christo's *Running Fence*, which plays on the qualities of natural light. We should also learn from the way an artist making public art must interact with society and its rules, like land use policies, environmental impact regulations, and other non-arts influences on the making of art.

Last, but far from least, to envisage the future, including one on Mars, we must consider the past. Given this, a few of the factoids take us back a hundred years or more to consider what was new, inventive, and innovative back then. In doing so, we find that in 1927, Americans celebrated Charles Lindberg's unprecedented flight across the Atlantic with a new social dance that exemplified the country's optimism and enthusiasm. Three years later, in more somber times nationally, Martha Graham was pioneering modern dance, creating a new vocabulary to articulate human experience. At almost the same time, a Russian émigré to America, Leon Theremin, was introducing audiences to something we would much later know as the synthesizer. Just as Graham and Teremin imagined and acted on their respective dreams, and profoundly changed dance and music in this century, so you, through the Mars Millennium Project, can imagine the arts on Mars and similarly influence arts in the next century.

Dancers' Jumps and Lifts

A dancer jumps vertically by exerting a vertical force downward against the floor greater than the body weight for a short time. When a partner is involved, the partner adds to the height of the jump by exerting a lifting force timed to coincide with the jumper's push against the floor. About three-quarters of the energy of the jump of the dancer being lifted comes from the force exerted by the lifting partner. Only about one-fourth is from the vertical jump of the dancer who is being lifted. (Source: *International Encyclopedia of Dance*)

Social Dance in Response to an Historic Aviation Event

Charles A. Lindberg's historic flight in 1927 inspired a new dance—the Lindy Hop, in which couples dance to a swing beat, doing difficult movements with seeming effortlessness. "The core of the Lindy was the so-called 'breakaway.' After doing a syncopated but flowing two-step together, the couples parted and went into solo improvisations to the same swinging beat..."

The Lindy Hop became mainstream after an organized group of dancers in 1935, known as Whitey's Lindy Hoppers, earned prizes at the First Harvest Moon Ball held at Madison Square Garden. The dancers were featured in a dance scene in the Marx Brothers' movie *A Day at the Races,* in which some of the aerobatic "air steps" that the young dancers had perfected were called "jitterbugging." (*Dancing,* p.179).

American Ballet

America's love for the ballet, a European art form, can be traced to enthusiasm for artists who visited our country in the mid-1800s. The enthusiasm for one artist, Fanny Elssler, an Austrian-born star of the Paris Opera Ballet in 1840, prompted the Congress to adjourn for a day in order to ensure that no one in government would be late for her performance. (*Dancing,* p. 131) .

"Under changing circumstances, ballet continues to find beauty in the struggles of the human body to overcome its limitations, to rise (often literally) above all constraints, and to leave a clear imprint of its improbable triumphs in the mind of the beholder." (Source: *Dancing,* p. 134).

Martha Graham 100 Years Before the Mars Habitat

Martha Graham, a pioneer of American modern dance, broke from the classical traditions in order to create a new vocabulary of movement that could "make visible the interior landscape" in a rapidly changing world.

In 1930, she performed her famous *Lamentation,* a solo in which "she's sitting on a wooden bench, shrouded in a tube of stretch jersey, with only her face, hands, and bare feet showing. Rocking stiffly from side to side, she tugged and pulled and pushed at the confining fabric with her hands, elbows, knees, and shoulders, not so much trying to break free as to carve out a place for rest for her grief-wracked body in a comfortless world." (*Dancing,* p. 205).

Principles of Art

A Color Circle is an arrangement of the hues of the spectrum in the order in which they appear in nature. The pairs opposite each other are complementary colors. The three complementaries of the three principal colors are called secondary colors. The remaining three pairs are called intermediate colors.

Three Dimensions of Color Classification

Hue is the common name for the color. The color spectrum is divided into seven hues: red, orange, yellow, green, blue, indigo and violet. Between these seven are intermediary hues.

Luminosity or ***value*** is the lightness or darkness of a color, which runs in gradations from light value to mid to dark value.

Intensity or ***saturation*** is the brightness or dullness of color, from high intensity or bright to middle to low intensity or dull.

To fully describe colors, we use all three. Thus, a red-orange of high luminosity and high intensity.

Art's Relationship to the Environment

Sculptors of the 20th century, such as the husband-and-wife team of Christo Javaceff and Jeanne-Claude Christo, explore our relationships with nature through "site specific" sculptures, ones in which the setting becomes a primary consideration. And, in some instances, public policies and organizations not usually thought of as being involved in the arts become important components of the artist's planning and implementation of a work. For instance, Christo's *Running Fence,* a curtain stretched across the California countryside to evidence the changing qualities of natural light, involved 18 public hearings, several judicial proceedings, the cooperation of 59 ranch owners, and the production of a nearly 500-page environmental study. In order to make their artistic vision a reality, over a four-year period (1972-'76), the artist team had to organize and manage the efforts of an array of professionals, volunteers, and even curious spectators. It took two weeks for a corps of 360 students to complete the installation by hanging the 24 miles of white nylon fabric.

Sometimes art directly addresses environmental concerns. The design of Byxbee Park in Palo Alto, California was a collaborative effort between landscape architect George Hargreaves and environmental sculptors Peter Richards and Michael Oppenheimer to create a park expressive of the place—a windy man-made site on the shore of San Francisco Bay. The project reclaimed a 36-acre landfill and now a beautiful park sits atop as much as 60 feet of garbage.

Principles of Music

Loudness and the nature of sound on an acoustical, stringed instrument depend on the transfer of vibrations from the strings to the sounding box (the body, such as that of a violin) and then to the air. The vibrating string is the generator of the sounds, the sounding box is the resonator. The sound or "f"holes on a violin have two functions: (1) to reduce stiffness of the floor of the bridge, and (2) to strengthen the sound in the lowest octave of the instrument. The sound holes form what is called a Helmholtz resonator. The special shape of the violin or other instrument reflects the sound waves back and forth, and by doing so, make the sound stronger and louder. The sound exits through the f-holes.

For wind instruments, sound is achieved through the relationship between the air column and a device that controls the flow of air. The two have to work in tandem to permit prompt and stable production of the notes in a musical scale. (Source: *Grove Encyclopedia of Music,* p. 77).

Music is sound and sound is a result of vibrations, but not all sources of vibrations are musical. Musical sounds have loudness, pitch, tone quality, and tone color.

Loudness is a function of the size or the amplitude of the vibrations. Big vibrations produce loud sounds; small vibrations, soft sounds.

Pitch is a function of the speed of the vibration. Frequency is the number of vibrations per second. Faster vibrations produce higher pitches; slower vibrations produce lower-frequency pitches. The human ear hears frequencies from 20 to 20,000 vibrations per second known technically as Hertz or Hz. The lowest note on a piano is at 30 vibrations per second; the highest note on the piano vibrates at 4,000 Hz.

Tone quality is the individual, characteristic sound of musical instruments and is produced not by a single tone but by a complex set of sound waves known as overtones or harmonics. These multiple vibrations blend with the sound of the basic note or fundamental, and vibrate two to three times as fast as the fundamental note. The combination of these tones is what gives each instrument its characteristic tone and distinctiveness.

Electronic Music

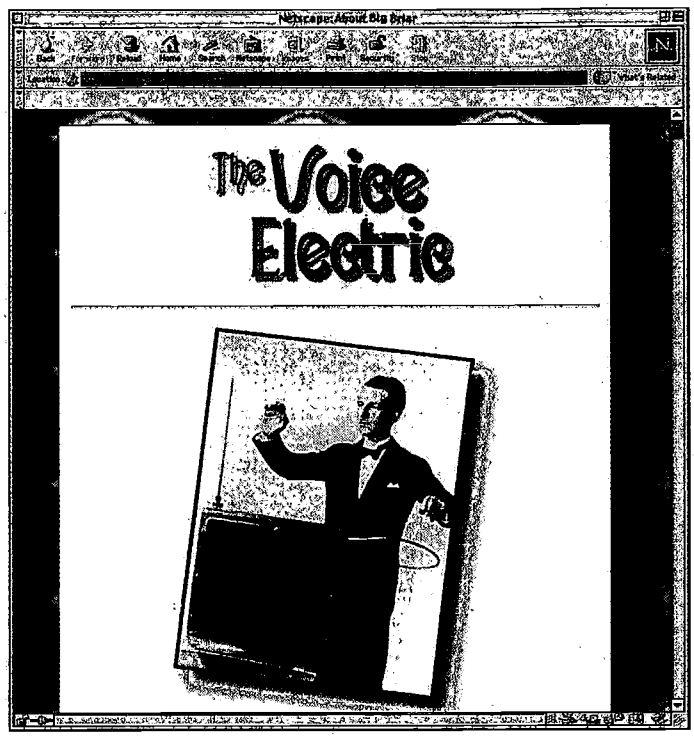
When did the first electronic music concert in America take place? Was it 1927, 1967, or 1987?

It was 1927! That's when Leon Theremin, a Russian-American scientist and amateur musician, demonstrated his invention, the "aetherophone," to an audience of musicians, scientists, and dignitaries in the Grand Ballroom of New York City's Plaza Hotel. This revolutionary musical instrument, later known as the "theremin," is the forerunner of today's music synthesizer. It worked in a deceptively simple fashion: Looking like a podium from which someone might speak, the cabinet sprouted two metal antennas, one connected to an oscillator producing a fixed frequency and the other to an oscillator emitting a variable frequency. The player never touches the instrument, but rather waves his hands in front of each of the antennas. One hand's movements controls the pitch; the other controls the volume, which is amplified through a loudspeaker.

With a wave of the one hand, sounds across the entire audio range are produced. And the sounds are best described as wavering and eerie, which is undoubtedly why Alfred Hitchcock used the theremin in the soundtracks of such films as *Spellbound* and *The Day the Earth Stood Still.* This unique instrument has been used in more recent times by such musicians as Brian Wilson of the Beach Boys (in "Good Vibrations") and Jimmy Page of Led Zeppelin ("Whole Lotta Love").

In the 1950s, 14-year-old Robert (Bob) Moog built his first theremin using a do-it-yourself article in *Radio News.* Today, Moog's name is synonymous with electronic music, and his company, Big Briar, develops and manufactures an array of electronic musical instruments, including Big Briar theremins.

For more information on Leon Theremin, the scientist-artist who was so ahead of his time, the musical instrument he invented, and the field of electronic music in general, check out these Web sites:



- *http://www.bigbriar.com/voice.htm* (pictured at right) contains "The Voice Electric," a brief history of the theremin, including photos from Bob Moog's personal collection. Here you can learn more about the extraordinary inventor Leon Theremin and Clara Rockmore, the classically trained musician who became a protégée of Theremin and performed concerts in the 1940s with major symphony orchestras to evidence the serious musical nature of the electronic instrument.

- *http://www.nashville.net/~theremin* is the location of the Theremin Home Page, which contains information on the inventor/scientist/artist. At the site, you can access information on the award-winning documentary film, *Theremin: An Electronic Odyssey* (1994), by Steven M. Martin. This 94-minute film chronicles the life of Leon Theremin in both his homeland of Russia and the United States, including footage of performances by both Theremin and Clara Rockmore.

A hard copy resource for more information is *Vintage Synthesizers: Groundbreaking Instruments and Pioneering Designers of Electronic Music Synthesizers*, by Mark Vail (1993). ISBN 0879302755. Available in paperback. Publisher: Miller Freeman Books.

National Standards for Arts Education (K–12)

http://artsedge.kennedy-center.org/cs/design/standards

1. Content Standard

Dance: Identifying and demonstrating movement elements and skills in performing dance.
Music: Singing, alone and with others, a varied repertoire of music.
Theater:

- K–4: Scriptwriting by planning and recording improvisations based on personal experience and heritage, imagination, literature, and history.
- 5–8: Scriptwriting by the creation of improvisations and scripted scenes based on personal experience and heritage, imagination, literature, and history.
- 9–12: Scriptwriting by improvising, writing, and refining scripts based on personal experience and heritage, imagination, literature, and history.

Visual Arts: Understanding and applying media, techniques, and processes.

2. Content Standard

Dance: Understanding choreographic principles, processes, and structures.
Music: Performing on instruments, alone and with others, a varied repertoire of music.
Theater:

- K–4: Acting by assuming roles and interacting in improvisations.
- 5–8: Acting by developing basic acting skills to portray characters who interact in improvised and scripted scenes.
- 9–12: Acting by developing, communicating, and sustaining characters in improvisations and informal or formal productions.

Visual Arts: Using knowledge of structures and functions.

3. Content Standard

Dance: Understanding dance as a way to create and communicate meaning.
Music: Improvising melodies, variations, and accompaniments.
Theater:

- K–4: Designing by visualizing and arranging environments for classroom dramatizations.
- 5–8: Designing by developing environments for improvised and scripted scenes.
- 9–12: Designing and producing by conceptualizing and realizing artistic interpretations for informal or formal productions.

Visual Arts: Choosing and evaluating a range of subject matter, symbols, and ideas.

4. Content Standard

Dance: Applying and demonstrating critical and creative thinking skills in dance.
Music: Composing and arranging music within specified guidelines.
Theater:

- K–4: Directing by planning classroom dramatizations.
- 5–8: Directing by organizing rehearsals for improvised and scripted scenes.
- 9–12: Directing by interpreting dramatic texts and organizing and conducting rehearsals for informal or formal productions.

Visual Arts: Understanding the visual arts in relation to history and cultures.

5. Content Standard

Dance: Demonstrating and understanding dance in various cultures and historical periods.
Music: Reading and notating music.
Theater:

- K–4: Researching by finding information to support classroom dramatizations.
- 5–8: Researching by using cultural and historical information to support improvised and scripted scenes.
- 9–12: Researching by evaluating and synthesizing cultural and historical information to support artistic choices.

Visual Arts: Reflecting upon and assessing the characteristics and merits of students' own work and the work of others.

6. Content Standard

Dance: Making connections between dance and healthful living.
Music: Listening to, analyzing, and describing music.
Theater:

- K–4: Comparing and connecting art forms by describing theater, dramatic media (such as film, television, and electronic media), and other art forms.
- 5–8: Comparing and incorporating art forms by analyzing methods of presentation and audience response for theater, dramatic media (such as film, television, and electronic media), and other art forms.
- 9–12: Comparing and integrating art forms by analyzing traditional theater, dance, music, and visual arts, and new art forms.

Visual Arts: Making connections between visual arts and other disciplines.

7. Content Standard

Dance: Making connections between dance and other disciplines.
Music: Evaluating music and music performances.
Theater:

- K–4: Analyzing and explaining personal preferences and constructing meanings from classroom dramatizations and from theater, film, television, and electronic media productions.
- 5–8: Analyzing, evaluating, and constructing meanings from improvised and scripted scenes and from theater, film, television, and electronic media productions.
- 9–12: Analyzing, critiquing, and constructing meanings from informal and formal theater, film, television, and electronic media productions.

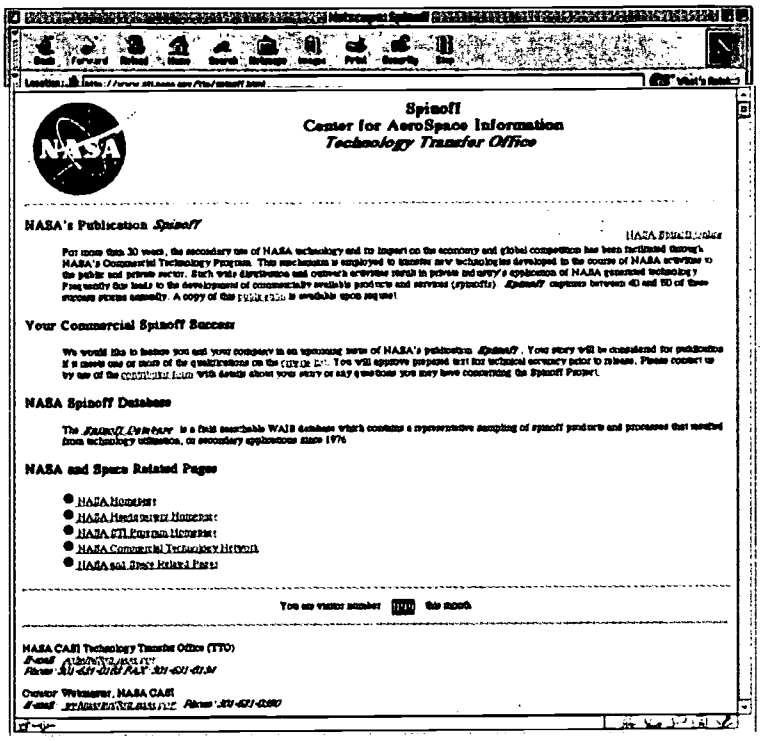
8. Content Standard

Music: Understanding relationships between music, the other arts, and disciplines outside the arts.
Theater:

- K–4: Understanding context by recognizing the role of theater, film, television, and electronic media in daily life.
- 5–8: Understanding context by analyzing the role of theater, film, television, and electronic media in the community and in other cultures.
- 9–12: Understanding context by analyzing the role of theater, film, television, and electronic media in the past and the present.

9. Content Standard

Music: Understanding music in relation to history and culture.



Alignment With the National Standards

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Science	X					X	X	X										
Math	X	X	X	X	X	X	X	X	X									
Geography																		X

NASA Educator Resource Centers

AK, Northern CA, HI, ID, MT, NV, OR, UT, WA, WY
NASA Educator Resource Center
Mail Stop 253-2
NASA Ames Research Center
Moffett Field, CA 94035-1000
Phone: (650) 604-3574

IL, IN, MI, MN, OH, WI
NASA Educator Resource Center
Mail Stop 8-1
John H. Glenn Research Center at Lewis Field
21000 Brookpark Road
Cleveland, OH 44135
Phone: (216) 433-2017

CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT
NASA Educator Resource Laboratory
Mail Code 130.3
NASA Goddard Space Flight Center
Greenbelt, MD 20771-0001
Phone: (301) 286-8570

CO, KS, NE, NM, ND, OK, SD, TX
JSC Educator Resource Center
Space Center Houston
NASA Johnson Space Center
1601 NASA Road One
Houston, TX 77058
Phone: (281) 244-2129

FL, GA, PR, VI
NASA Educator Resource Center
Mail Code ERC
NASA Kennedy Space Center
Kennedy Space Center, FL 32899
Phone: (407) 867-4090

KY, NC, SC, VA, WV
Virginia Air & Space Center
Educator Resource Center for
NASA Langley Research Center
600 Settler's Landing Road
Hampton, VA 23669-4033
Phone: (757) 727-0900 x 757

AL, AR, IA, LA, MO, TN
U.S. Space and Rocket Center
NASA Educator Resource Center for
NASA Marshall Space Flight Center
One Tranquility Base
Huntsville, AL 35758
Phone: (205) 544-5812

MS
NASA Educator Resource Center
Building 1200
NASA John C. Stennis Space Center
Stennis Space Center, MS 39529-6000
Phone: (228) 688-3338

NASA JPL Educator Resource Center
Village at Indian Hills Mall
1460 East Holt Avenue, Suite 20
NASA Jet Propulsion Laboratory
Pomona, CA 91767
Phone: (909) 397-4420

AZ, Southern CA
NASA Educator Resource Center for
NASA Dryden Flight Research Center
45108 N. 3rd Street East
Lancaster, CA 93535
Phone: (661) 948-7347

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GSFC/Wallops Flight Facility
Wallops Island, VA 23337
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NASA Topics, Activities (Aligned with National Content Standards), and Resources

Question 1: What is a community?

A. How do scientific aspects of community affect human life?

Topics to Explore

- People and the basic needs of food, water, air, and habitat (place to live)
- Earth's surface features, atmosphere, chemistry, and energy
- Earth's changes over time and how these changes have influenced your community
- Ways humans have had an impact on Earth's surface, atmosphere, natural resources, and environment
- Environmental concerns that affect the health of people in a community
- The role of technology in solving human needs/problems

Possible Activities:

- Brainstorm with students the basic needs to sustain human life such as air, water, and a habitat (a place to live). List student responses on a chart with students discussing why these needs are necessary to human life. Discuss how Earth as a system has met human needs in the past.

Suited for Spacewalking, A Teacher's Guide with Activities for Technology Education, Mathematics, and Science EG-1998-03-112-HQ Educators, Grades 5-12
http://spacelink.nasa.gov/products

Teachers and Students Investigating Plants in Space, A Teacher's Guide with Activities for Life Sciences EG-1997-02-113-HQ Educators, Grades 5-12
http://spacelink.nasa.gov/products

- Have students interview grandparents or older members of the community to find out how life in their community was different. How has the Earth changed over time and what has caused these changes?

http://kids.earth.nasa.gov/
For Kids Only: NASA Earth Science Enterprise

http://edcwww.cr.usgs.gov/earthshots/slow/tableofcontents
The U.S. Geological Survey Web site, "EarthShots Satellite Images of Environmental Change"—Includes articles on agriculture, city, desert, forest, geology, water, and wildlife that depict global environmental change. Each article is illustrated with satellite imagery and photographs.

- Discuss how humans have had an impact on Earth, causing changes to occur to its surface, atmosphere, and availability of natural resources. In small groups, have students select one of these topics to explore through research. Each group should design a way to communicate their findings to the rest of the class.

Geography From Space, Liftoff to Learning Series, A Videotape for Earth and Space Science, Life Science, and Science in Personal and Social Perspectives EV-1997-07-005-HQ Educators, Grades K-8 (CORE)

Our Water Planet from Space. NASA On the Cutting Edge Educational Live Show EV-1998-09-016-HQ Educators, Grades 5-8 (CORE)
http://edcww.cr.usgs.gov/earthshots/slow/tableofcontents

- Invite resource people to your classroom to talk about environmental concerns that impact people's health.
- Visit the local water treatment plant to see how water is treated for human use and consumption.

http://www.epa.gov/OST/KidsStuff/
http://www.epa.gov/OST/

- Encourage students to brainstorm and research how technology has played a key role in helping to solve problems and address the needs of human existence on the planet Earth. Discuss how technologies have been developed and later modified to meet changing needs and to solve new problems.

Aeronautics, An Educator's Guide with Activities in Science, Mathematics, and Technology Education EG-1998-09-105-HQ Educators, Grades K-4
http://spacelink.nasa.gov/products

http://www.sti.nasa.gov/tto/spinoff.html
NASA Spinoff, technologies from NASA found in the private sector.

- Hold a debate in the classroom with students discussing some of the problems/issues that might arise from the development of new technologies. Encourage students to discuss why it is important to examine the pros and cons of these issues before making decisions about the use of new technology.

B. How does one community differ from another community?

Topics to Explore
- Community differences based on geographic location (i.e., urban vs. rural, land structure, climate, weather, accessibility)
- Community differences based on availability of natural resources
- Community differences based on industrialization, mining, and farming. How have these differences affected Earth's atmosphere and surface features?

Possible Activities
- Visit a community that is different from your own. Some differences might include landforms (Earth's surface), rural versus urban, natural resources available, or industrial vs. farming. Look for human impact on the community. Collect soil and water samples to analyze once you return to your class. Compare them with samples from your own community.

http://geo.arc.nasa.gov/sge/jskiles/top-down/intro_product/title-page.html
Understanding the Biosphere From the Top Down: Earth Science Teacher's Guide,
Grades 4-12 *http://spacelink.nasa.gov/products*

- Have students create murals or posters depicting the differences in the two communities.
- Interview a specific number of people in your community and in a community you visited that is unlike your own. Find out why these people decided to settle in that community. Graph the data you collect and make comparisons.
- Complete Venn diagrams to compare two different communities. Differences and similarities among the two communities should be identified and represented on the diagram. Discuss how people have adapted to the specific characteristics of their community.

Alignment With the National Standards

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Science	X			X	X		X	X										
Math	X	X	X	X	X	X	X	X	X									
Geography		X		X			X				X	X	X	X	X	X		

Question 2: How would your community be different on Mars?

A. What is Mars like?

Topics to Explore

- The atmosphere of Mars
- The surface of Mars
- The near-Mars surface
- Chemistry on Mars
- Energy on Mars
- Indigenous life on Mars

Possible Activities

- Visit the library or the Internet to access information about Mars' atmosphere and surface features. Is there air on Mars? Is there gravity? Is water present? What is the climate and temperature on Mars? Based on scientific exploration, is there evidence of changes in atmosphere or surface over time?
- Work in teams to design and construct a prototype spacesuit for working on Mars.

http://www.challenger.org/mmp
Challenger Center, Exploring the Surface of Mars

http://pds.jpl.nasa.gov/planets/welcome/mars.htm
Welcome to the Planets/Mars

http://nssdc.gsfc.nasa.gov/planetary/planets/marspage.html
Mars at the National Space Science Data Center

Exploring the Moon; A Teacher's Guide with Activities for Earth and Space Sciences EG-1997-10-116-HQ Educators, Grades 4-12 *http://spacelink.nasa.gov/products*

Planetary Geology; A Teacher's Guide with Activities in Physical and Earth Sciences EG-1998-03-109-HQ Educators & Students, Grades 5-12 *http://spacelink.nasa.gov/products*

- Research what space is like near Mars and whether the space environment has changed over time.

http://nssdc.gsfc.nasa.gov/planetary/planetaryfaq.html#Mars
http://ssdoo.gsfc.nasa.gov/education/education_home.html

Exploring Meteorite Mysteries; A Teacher's Guide with Activities for Earth and Space Sciences EG-1997-08-104-HQ Educators, Grades 5-12 *http://spacelink.nasa.gov/products*

Planetary Geology; A Teacher's Guide with Activities in Physical and Earth Sciences EG-1998-03-109-HQ Educators & Students, Grades 5-12 *http://spacelink.nasa.gov/products*

- Research other aspects of Mars, such as the forms of energy that might reach Mars. Do energy cycles exist on Mars?

http://mars.jpl.nasa.gov/MPF/science/science-index.html
Mars Pathfinder Science Index

- Read about the 1997 Mission to Mars. Find out what was learned about the chemistry of Mars. What elements and compounds exist? What chemical systems can be found? Discuss any evidence that scientists have to suggest changes in Mars' chemical systems over time.

http://eis.jpl.nasa.gov/~skientz/little_rock/
The Story of a Little Rock on Mars

http://mars.jpl.nasa.gov/MPF/mpf-pressrel.html
Nov. 4, 1997 Mars Pathfinder Winds Down After Phenomenal Mission press release

http://mars.jpl.nasa.gov/MPF/science/science-index.html
Mars Pathfinder Science Index

- Find out about indigenous life on Mars. Is there scientific evidence of life on Mars? Has life ever existed on Mars?

http://rsd.gsfc.nasa.gov/marslife/index.html
Life on Mars?

- Investigate magazine and newspaper articles from August 1996 and March 1999 about the discovery of Martian meteorites that have led to discussion about the possibility of primitive life on Mars.

http://www.seti.org/howlife.html
How Might Life Evolve on Other Worlds?

http://astrobiology.arc.nasa.gov/overview.html; Mars-Primitive Life Research
NASA Astrobiology: The Study of the Living Universe

http://spacelink.nasa.gov/NASA.Projects/Space.Science/Solar.System/Mars-Primitive.Life.Research/.index.html
Mars-Primitive Life Research

B. How has technology allowed us to learn about Mars? How might technology in the future allow us to know more?

Topics to Explore
- Robotic Spacecraft
- Mars Surveyor
- Viking Orbiter
- Mars Pathfinder
- Hubble Telescope

Possible Activities
- Find out about the technology that enabled humans to know what we know about Mars. Develop a timeline to show what we have learned about Mars over time. What technologies have enabled us to push the limits in our exploration? What limitations have scientists had in learning more about Mars?

Rockets; A Teacher's Guide with Activities in Science, Mathematics, and Technology EG-1996-09-108-HQ Educators, Grades K-12 *http://spacelink.nasa.gov/products*

Suited for Spacewalking; A Teacher's Guide with Activities for Technology Education, Mathematics and Science EG-1998-03-112-HQ Educators, Grades 5-12 *http://spacelink.nasa.gov/products*

Let's Talk Robotics; Liftoff to Learning Series, A Videotape for Technology Education and Physical Science EV-1998-04-015-HQ Educators, Grades 5-12 (CORE)

Living In Space, Liftoff to Learning Series, A Videotape for Life Science and Physical Science EV-1997-07-007-HQ Educators, Grades K-3 (CORE)

http://www-spof.gsfc.nasa.gov/stargaze/Sintro.htm
"From Stargazers to Starships" deals with the world of gravity, massive planets, and stars, and the way spaceflight is achieved despite their strong pull. The material is suitable for high school students and gives historical background as well as the latest scientific findings.

- Build a model of the Pathfinder. How might engineers modify it for future missions to Mars?

http://www.challenger.org/mars.html
Challenger Center for Space Science Education Mars Pathfinder Lander model

http://redrover.planetary.org/
Red Rover, a project developed by The Planetary Society, Visionary Products Inc. and the LEGO Company. Red Rover, Red Rover permits teleoperation of model LEGO rovers in simulated Mars terrains. Schools, science centers, students, and adults worldwide engage in a simulation of the robotic control of rovers on Mars.

http://mars.jpl.nasa.gov/MPF/rovercom/pix.html
Mars Microrover Homepage

C. How would a community on Mars be like your Earth community? How would it be different?

Topics to Explore
- How position and motion affect Earth and Mars
- Similarities and differences in the surface features of Earth and Mars
- Similarities and differences in the atmosphere of Earth and Mars
- Comparison of Mars's and Earth's chemistries
- Comparison of energy systems on Mars and Earth
- Human impact on Mars and Earth

Possible Activities
- Build a model of the solar system. Focus on Earth and Mars and their relative size, position, and motion within the solar system. Discuss how these factors would impact temperature, weather, climate, and life on Earth and Mars.

Solar System Puzzle Kit, An Activity for Earth and Space Science EP-1997-04-356-HQ Educators and Students, grades 5-12 *http://spacelink.nasa.gov/products*

- Compare the atmosphere and surface features of Earth and Mars. Which features of Earth allow humans to have their basic needs met? Discuss how these would be different on Mars.

http://pds.jpl.nasa.gov/planets/welcome/earth.htm
http://pds.jpl.nasa.gov/planets/welcome/mars.htm
Welcome to the Planets

http://nssdc.gsfc.nasa:gov/planetary/planets/earthpage.html
http://nssdc.gsfc.nasa.gov/planetary/planets/marspage.html
Mars at the National Space Science Data Center

- Identify and discuss Earth's natural resources. Develop a list of ways these natural resources positively affected the lives of Earth's inhabitants. How would this be different or the same on Mars? How would humans have to modify their lives if they were on Mars?

Exploring Meteorite Mysteries: A Teacher's Guide with Activities for Earth and Space Sciences EG-1997-08-104-HQ Educators, Grades 5-12 *http://spacelink.nasa.gov/products*

Planetary Geology: A Teacher's Guide with Activities in Physical and Earth Sciences EG-1998-03-109-HQ Educators and Students, Grades 5-12 *http://spacelink.nasa.gov/products*

Geography From Space; Liftoff to Learning Series, A Videotape for Earth and Space Science, Life Science, and Science in Personal and Social Perspectives EV-1997-07-005-HQ Educators, Grades K-8 (CORE)

- Look for ways humans have had an impact on Earth. Divide into classroom teams and debate the pros and cons of this impact. Would these be the same on Mars? What are the factors you would want to be considered if Martians, for example, were to come to your planet to establish a new community?

http://www-sn.jsc.nasa.gov/EXPLORE/explore.htm
The Reference Mission of the NASA Mars Exploration Study Team, 1997

Office of Technology Assessment: Science & Technology reports

Alignment With the National Standards

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Science	X	X	X		X	X	X	X										
Math	X	X	X	X	X	X	X		X									
Geography				X			X					X		X	X	X		

Question 3: What makes life in your community meaningful?

A. What are the characteristics of our humanity that give meaning to life in a community? How does having our basic needs met play a part in this process?

Topics to Explore

- Human physical needs, such as air, water, food, and a place to live
- Societal needs such as common understanding of responsibilities of the group and its individuals

Possible Activities

- Examine the physical needs of humans. What does Earth provide that allows us to satisfy our physical needs? Would human physical needs be different on Mars? How could these needs be satisfied on Mars?

http://www-sn.jsc.nasa.gov/EXPLORE/explore.htm
The Reference Mission of the NASA Mars Exploration Study Team, 1997

http://www.challenger.org/mmp
Challenger Center, Exploring the Surface of Mars

Suited for Spacewalking, A Teacher's Guide with Activities for Technology Education, Mathematics and Science EG-1998-03-112-HQ Educators, Grades 5-12 *http://spacelink.nasa.gov/products*

The Brain in Space, A Teacher's Guide with Activities for Neuroscience EG-1998-03-118-HQ Educators, Grades 5-12 *http://spacelink.nasa.gov/products*

All Systems Go; Liftoff to Learning Series, A Videotape for Life Science and Physical Science EV-1997-07-001-HQ Educators, Grades 5-12 (CORE)

Go For EVA; Liftoff to Learning Series, A Videotape for Physical Science, History and Nature of Science, and Science and Technology EV-1997-07-006-HQ Educators, Grades K-8 (CORE)

Living in Space; Liftoff to Learning Series, A Videotape for Life Science and Physical Science EV-1997-07-007-HQ Educators, Grades K-3 (CORE)

- Brainstorm the societal needs of humans on Earth. Would these needs be different on Mars?

http://spaceflight.nasa.gov/history/index.html
Report on the "Phase1," Americans on Mir Program

http://www-sn.jsc.nasa.gov/EXPLORE/explore.htm
The Reference Mission of the NASA Mars Exploration Study Team, 1997

B. What other human factors bring meaning to community?

Topics to Explore

- The role of careers/jobs to human fulfillment
- The role of technology in transportation, communication, and health
- The desire for personal possessions

Possible Activities

- Have a career day at school. Invite parents and/or others from the community to discuss how their careers have added meaning to their lives.

- Divide the class into career groups. Which careers would be needed on Mars? Which careers would be obsolete and why? Would there be a necessity to create new careers on Mars? Answer these questions in group presentations.

http://www-sn.jsc.nasa.gov/EXPLORE/explore.htm
The Reference Mission of the NASA Mars Exploration Study Team, 1997

Superstars of Spaceflight, Your Attitude Determines Your Altitude, an educational wall sheet, WED-120
http://spacelink.nasa.gov/products

- Allow students to choose five personal items from home to take to Mars. Why would these be the most valuable things to have on the planet Mars? How would they add meaning to human life?

Murmurs of Earth: The Voyager Interstellar Record, Sagan, Carl et al. (1978). Ballantine Publishing. This book documents the background to the Voyager mission out of our solar system focusing on the artworks and music carried aboard the spacecraft to represent Earth's culture.

- Examine the technologies that have enhanced life on Earth. Which technologies would be useful on Mars? How might these technologies be modified for use on Mars?

Rockets; A Teacher's Guide with Activities in Science, Mathematics, and Technology EG-1996-09-108-HQ Educators, Grades K-12 *http://spacelink.nasa.gov/products*

Let's Talk Robotics; Liftoff to Learning Series, A Videotape for Technology Education and Physical Science EV-1998-04-015-HQ Educators, Grades 5-12 (CORE)

Alignment With the National Standards

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Science	X					X	X	X										
Math	X	X	X	X	X	X	X	X	X	X								
Geography				X									X					

Question 4: How would you create and represent your Mars community?

A. How will your community on Mars provide for the physical needs of your population?

Topics to Explore
- Water
- Food
- Air
- Habitat

Possible Activities
- Consider how water will be obtained on Mars. Where will it come from? How will you get it? How will you keep it? How much can each person use? How will you recycle it? How will you ensure water quality?

Planetary Geology: A Teacher's Guide with Activities in Physical and Earth Sciences EG-1998-03-109-HQ Educators and Students, Grades 5-12 *http://spacelink.nasa.gov/products*

International Space Station Clean Water ET-1998-07-002-HQ Educators, Grades K-4
http://spacelink.nasa.gov/products

Water Is a Force of Change lithograph HqL-401 *http://spacelink.nasa.gov/products*

Our Water Planet from Space; NASA...On the Cutting Edge Educational Live Show EV-1998-09-016-HQ Educators, Grades 5-8 (CORE)

http://www.epa.gov/OST/KidsStuff/
http://www.epa.gov/OST/

- Investigate growing food hydroponically. Try growing seeds this way. Which seeds are easiest to bring full cycle? Identify some of the problems with this method of growing food.

Teachers and Students Investigating Plants in Space; A Teacher's Guide with Activities for Life Sciences EG-1997-02-113-HQ Educators, Grades 5-12 *http://spacelink.nasa.gov/products*

Exploring the Moon; A Teacher's Guide with Activities for Earth and Space Sciences EG-1997-10-116-HQ Educators, Grades 4-12 *http://spacelink.nasa.gov/products*

International Space Station Clean Water ET-1998-07-002-HQ Educators, Grades K-4 *http://spacelink.nasa.gov/products*

Plants In Space; Liftoff to Learning Series, A Videotape for Biology and Life Science EV-1998-12-017-HQ Educators, Grades 5-12 (CORE)

- Plan how much water, food, and air will be needed for your community on Mars.

http://www-sn.jsc.nasa.gov/EXPLORE/explore.htm
The Reference Mission of the NASA Mars Exploration Study Team, 1997

Teachers and Students Investigating Plants in Space; A Teacher's Guide with Activities for Life Sciences EG-1997-02-113-HQ Educators, Grades 5-12 *http://spacelink.nasa.gov/products*

- Devise a system for handling waste in your Mars community. What new technology might be needed for this and why?

http://www-sn.jsc.nasa.gov/EXPLORE/explore.htm

The Reference Mission of the NASA Mars Exploration Study Team, 1997

http://www.epa.gov/epaoswer/osw/kids.htm
"Office of Solid Waste Kids' Page"—Collection of games and puzzles that teach kids about solid waste disposal and its problems. Some files require a free downloadable Adobe Acrobat reader (EPA)

- Design a habitat for Mars. What will it look like? What will it provide? How many habitats will you need for the population of your community? Of what materials will it be made? What effects might this habitat have on the Martian environment?

http://www.challenger.org/
Marsville and Mars City Alpha from the Challenger Center for Space Science Education

http://www-sn.jsc.nasa.gov/EXPLORE/explore.htm
The Reference Mission of the NASA Mars Exploration Study Team, 1997

B. How will your community on Mars provide for the societal needs of your population?

Topics to Explore
- The need to belong—the individual's need to be a member of the community
- The role of careers/jobs within community
- The need to communicate
- The role of transportation
- The need to maintain health

Possible Activities
- Plan a day's schedule within the Martian habitat. What will people be doing? How will they be interacting? How will conflicts be handled? How will the inhabitants communicate with Earth? What are the different ways they will communicate with each other? What technologies will allow this to happen? Will these be new technologies or will current technologies suffice? Will these technologies need to be changed or modified for the atmosphere on Mars?

http://www-sn.jsc.nasa.gov/EXPLORE/explore.htm
The Reference Mission of the NASA Mars Exploration Study Team, 1997

- Plan how people will travel to and from Mars. How will they travel once they arrive? Will there be a need to travel outside the habitat? If so, why? Discuss the technology and any changes to current technology that would be needed to make this possible. Design a vehicle to travel on the surface of Mars.

Go For EVA; Liftoff to Learning Series, A Videotape for Physical Science, History and Nature of Science, and Science and Technology EV-1997-07-006-HQ Educators, Grades K-8 (CORE)

Let's Talk Robotics; Liftoff to Learning Series, A Videotape for Technology Education and Physical Science EV-1998-04-015-HQ Educators, Grades 5-12 (CORE)

Rockets: A Teacher's Guide with Activities in Science, Mathematics, and Technology EG-1996-09-108-HQ Educators, Grades K-12 *http://spacelink.nasa.gov/products*

- Invite someone from your health services community to your classroom. Share with them what you have learned about Mars. Ask them what effects living in the Mars environment might have on the health and well-being of the inhabitants.

All Systems Go; Liftoff to Learning Series, A Videotape for Life Science and Physical Science EV-1997-07-001-HQ

Educators, Grades 5-12 (CORE)

http://www-sn.jsc.nasa.gov/EXPLORE/explore.htm
The Reference Mission of the NASA Mars Exploration Study Team, 1997

- Devise a health plan for the inhabitants of your community. How will illness and communicable disease be handled in the Mars habitat?

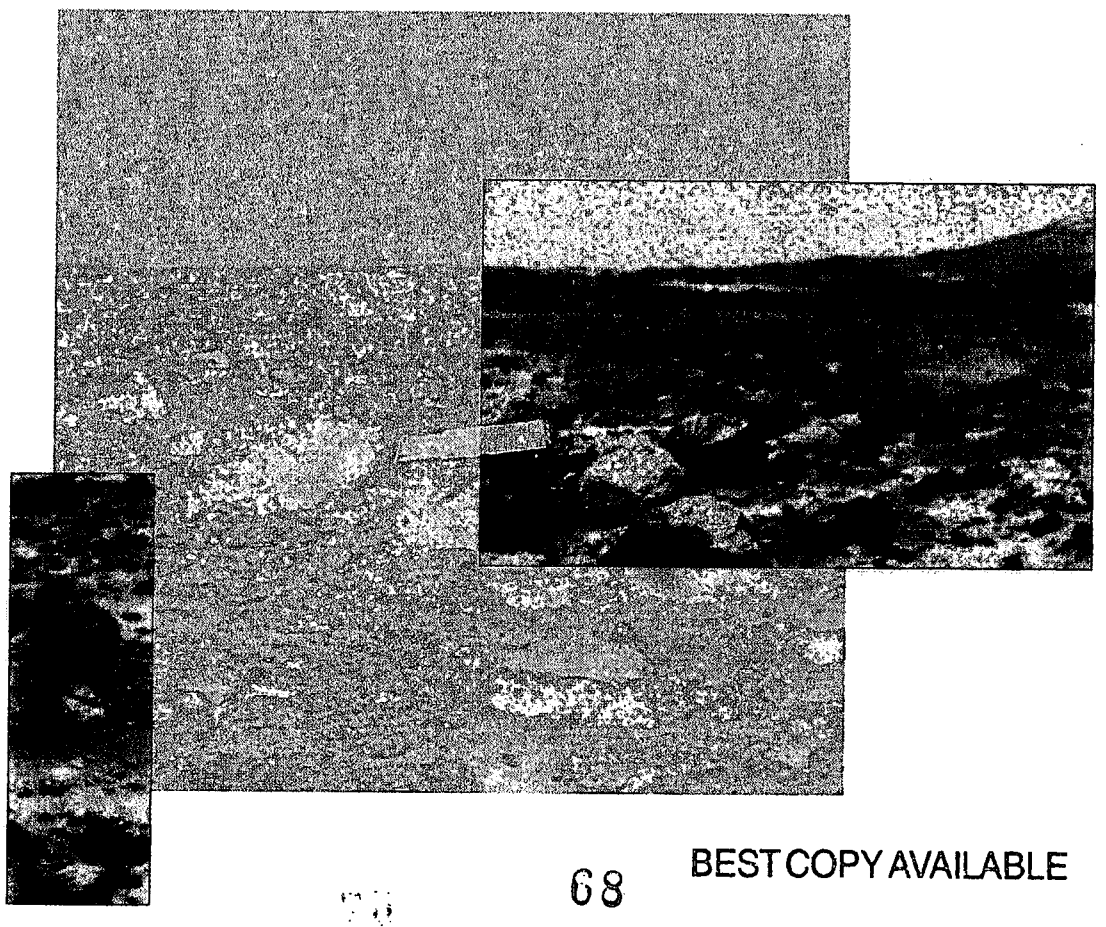
http://www-sn.jsc.nasa.gov/EXPLORE/explore.htm
The Reference Mission of the NASA Mars Exploration Study Team, 1997

- Discuss current technology that contributes to good health on Earth. How could this technology be used on Mars? Knowing what you know about the environment, how would the technology need to be changed?

http://www.sti.nasa.gov/tto/spinoff.html
NASA Spinoff, technologies from NASA found in the private sector

Alignment With the National Standards

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Science	X	X	X	X		X	X	X										
Math	X	X	X	X	X	X	X	X	X									
Geography	X	X	X															



Question 5: How can you begin today to make your community on Earth better?

A. What qualities or aspects of your new Mars community would you most like to bring back to your Earth community in the next year? In five years? By 2030?

Topics to Explore
- Physical systems
- Societal systems

Possible Activities
- Examine the habitat you created on Mars. What are some of the positive aspects of the habitat that might be adapted to Earth? How would the aspects you identified improve life on Earth? Can they reduce the depletion of Earth's natural resources? If so, how?

http://www.challenger.org/
Marsville and Mars City Alpha from the Challenger Center for Space Science Education

- Discuss how the societal needs of your Mars community were met. What positive aspects could you identify that might be useful on Earth? For example, how did people work together within the community for survival? Were members of the community interdependent? What problems resulted, and what solutions were developed?

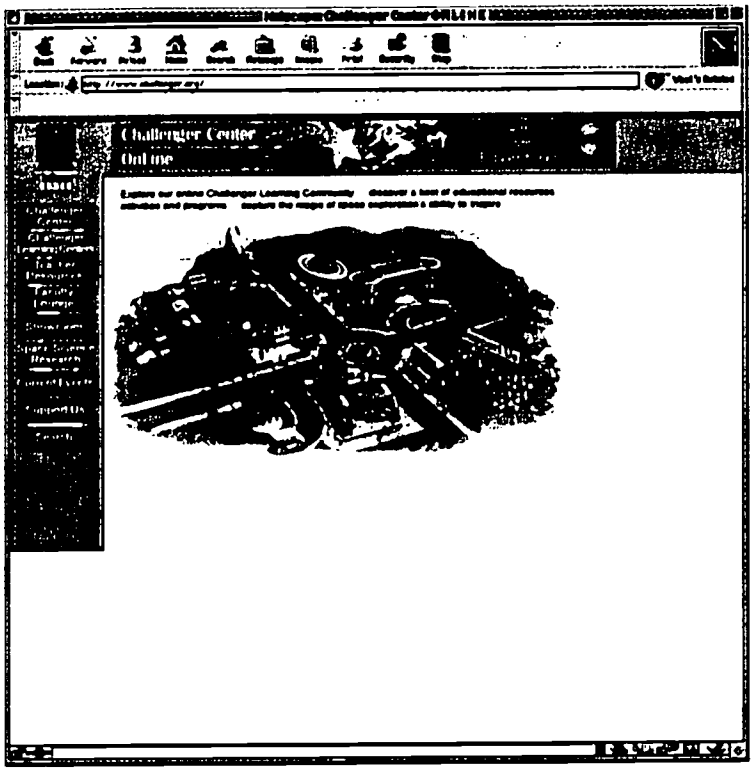
http://www.challenger.org/
Marsville and Mars City Alpha from the Challenger Center for Space Science Education

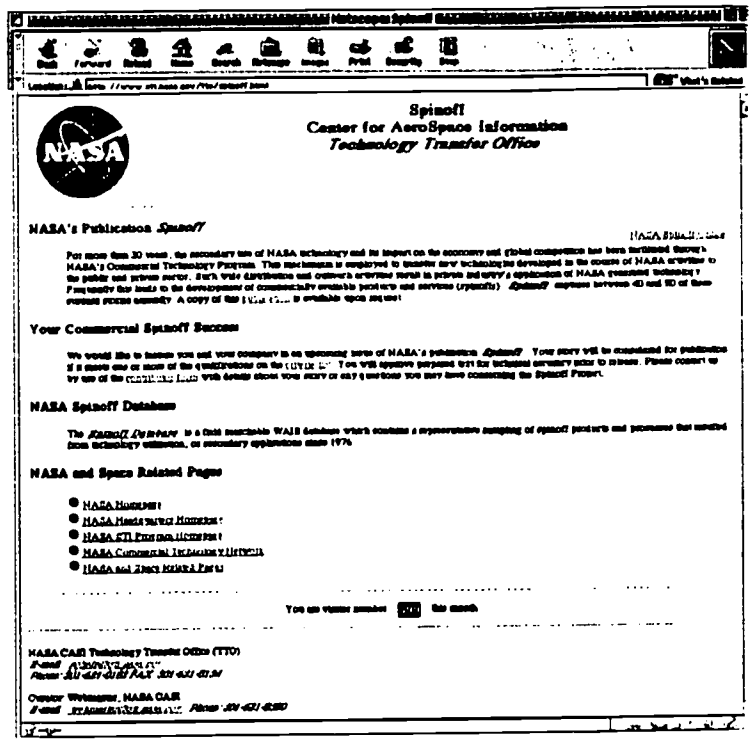
B. What new or modified technologies were useful to your Mars community? How did these technologies help to solve problems within the community?

Topics to Explore
- Transportation technology
- Technology for communication
- Technology to improve health and health services

Possible Activities
- Use the Internet or other resources to identify how technology designed for NASA's space program has positively affected human existence on Earth.
- Think about the ideas you had for new and improved technologies to solve problems of living on Mars. What possible spin-offs do you see that might improve life in your Earth community?

http://www.sti.nasa.gov/tto/spinoff.html
NASA Spinoff, technologies from NASA found in the private sector





Alignment With the National Standards

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Science	X					X	X	X										
Math	X	X	X	X	X	X	X	X	X									
Geography																		X

National Research Council Science Content Standards (K–12)

http://bob.nap.edu/readingroom/books/nses/html/overview.html#content

1. Unifying Concepts and Processes
2. Science as Inquiry
3. Physical Science
   - K–4 (properties of objects and materials, position, and motion of objects, light, heat, electricity, and magnetism)
   - 5–8 (properties and changes of properties in matter, motions and forces, transfer of energy)
   - 9–12 (structure of atoms, structure and properties of matter, chemical reactions, motions, and forces, conservation of energy and increase in disorder, interactions of energy, and matter)
4. Life Science
   - K–4 (characteristics of organisms, life cycles of organisms, organisms, and environments)
   - 5–8 (structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, diversity and adaptations of organisms)
   - 9–12 (the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, organization in living systems, behavior of organisms)
5. Earth and Space Science
   - K–4 (properties of Earth materials, objects in the sky, changes in Earth and sky)
   - 5–8 (structure of the Earth system, Earth's history, Earth in the solar system)
   - 9–12 (energy in the Earth system, geochemical cycles, origin and evolution of the Earth system, origin and evolution of the universe)
6. Science and Technology
7. Science in Personal and Social Perspectives
8. History and Nature of Science

NCTM Mathematics Content Standards (K–12)

http://standards-e.nctm.org/1.0/89ces/Table_of_Contents.html

1. Number and Operation (understand relationships among numbers, the meanings of operations, estimation, use of computational tools)
2. Patterns, Functions, and Algebra (understand types of patterns and functional relationships, use of symbols to represent/analyze mathematical situations, and the use of mathematical concepts)
3. Geometry and Spatial Sense (understand different representational systems [verbal, numerical, graphical, geometrical, or symbolic], use visualization and spatial reasoning to solve problems)
4. Measurement (understand units of measurement and apply a variety of techniques for determining measurements)
5. Data Analysis, Statistics, and Probability (pose questions, collect, organize, and represent data to answer these questions; interpret data, develop, and evaluate information based upon the data; understand and apply notions of chance and probability)
6. Problem Solving (build new mathematical knowledge; formulate, represent, abstract, and generalize; apply a wide variety of strategies to solve problems and adapt the strategies to new situations; monitor and reflect on their mathematical thinking in solving problems)
7. Reasoning and Proof (make and investigate mathematical conjectures and develop/evaluate mathematical arguments and proofs)
8. Communication (organize and consolidate their mathematical thinking to communicate with others; express mathematical ideas coherently; extend their mathematical knowledge by considering the thinking and strategies of others)
9. Connections (understand how mathematical ideas build on one another to produce a coherent whole; recognize, use, and learn about mathematics in contexts outside of mathematics)

10. Representation (create and use representations to organize, record and communicate mathematical ideas; use representations to model and interpret physical, social, and mathematics phenomena)

National Geography Standards (K–12)

http://www.nationalgeographic.com/education/xpeditions/main.html?STST=standards&STN=5

The World in Spatial Terms

1. How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective
2. How to use mental maps to organize information about people, places, and environments in a spatial context
3. How to analyze the spatial organization of people, places, and environments on Earth's surface

Places and Regions

4. The physical and human characteristics of places
5. That people create regions to interpret Earth's complexity
6. How culture and experience influence people's perceptions of places and regions

Physical Systems

7. The physical processes that shape the patterns of Earth's surface
8. The characteristics and spatial distribution of ecosystems on Earth's surface

Human Systems

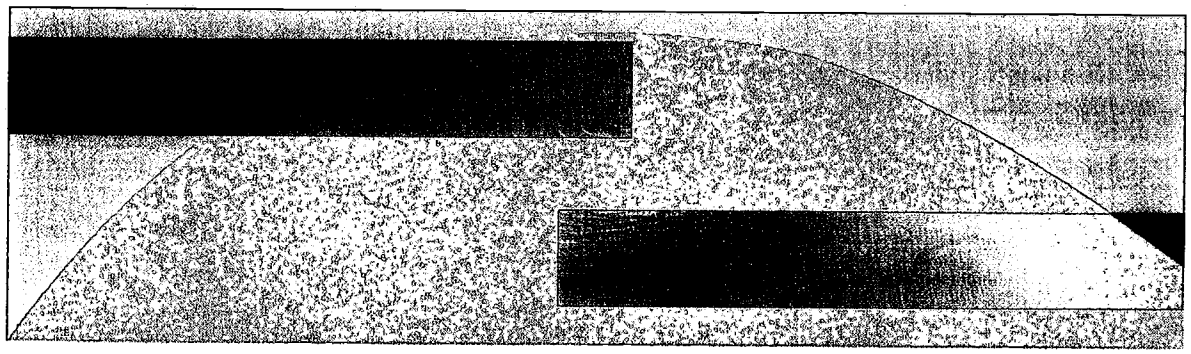
9. The characteristics, distributions, and migration of human populations on Earth's surface
10. The characteristics, distribution, and complexity of Earth's cultural mosaics
11. The patterns and networks of economic interdependence on Earth's surface
12. The processes, patterns, and functions of human settlement
13. How the forces of cooperation and conflict among people influence the division and control of Earth's surface

Environment and Society

14. How human actions modify the physical environment
15. How physical systems affect human systems
16. The changes that occur in the meaning, use, distribution, and importance of resources

The Uses of Geography

17. How to apply geography to interpret the past
18. How to apply geography to interpret the present and plan for the future



A Selected Annotated Bibliography on Martian Exploration

Baker, Victor R. *The Channels of Mars.* Austin: University of Texas Press, 1982. A detailed scientific study of the features seen from Earth that were first popularized as canals.

Batson, R.M.; Bridges, P.M. Bridges; and Inge, J.L. *Atlas of Mars: The 1:5M Map Series.* Washington, DC: NASA Special Publication-438, 1979. Perhaps the best maps available of the planet, based on data returned from the Viking project that arrived at the planet in 1976.

Bizony, Piers. *The Rivers of Mars: Searching for the Cosmic Origins of Life.* London, England: Aurum Press, 1997. A popularly written account of the search for life on Mars containing an account of the discoveries first publicized in August 1996 about the possibility of past Martian life contained in a meteorite.

Bradbury, Ray; Clarke, Arthur C.; Murray, Bruce C.; and Sagan, Carl. *Mars and the Mind of Man.* New York: Harper and Row, 1973. A thoughtful analysis by a collection of authors, this book discusses the place of the planet Mars in the mythology and science of humanity from the ancients to the late twentieth century.

Braun, Wernher von. *The Mars Project.* Urbana: University of Illinois Press, 1953. Originally published in Germany in 1952, this important study describes in detail the technical and scientific attributes of a human expedition to Mars that the author says was feasible in the mid-1950s.

Burgess, Eric. *To the Red Planet.* New York: Columbia University Press, 1978. A very good general interest discussion of what has been learned about Mars from several probes, including the Viking mission in the 1970s.

_____, and Barbree, Jay, with Wright, Susan. *Destination Mars: In Art, Myth, and Science.* New York: Penguin Studio, 1997. A broad cultural survey of the meaning of Mars in Western civilization.

Carr, Michael H. *The Surface of Mars.* New Haven, CT: Yale University Press, 1981. A scientific investigation of the geological features of Mars.

_____. *Water on Mars.* New York: Oxford University Press, 1996. Discusses the scientific possibility that Mars might once have contained water, a critical component of life as its exists on Earth.

Clarke, Arthur C. *The Snows of Olympus—A Garden on Mars: The Illustrated Story of Man's Colonization of Mars.* New York: W.W. Norton and Co., 1996. An exciting vision of human exploration of the Red Planet.

Collins, Michael. *Mission to Mars: An Astronaut's Vision of Our Future in Space.* New York: Grove Weidenfeld, 1990. An argument on behalf of an aggressive exploration of the Red Planet, including a recapitulation of the earlier advocacies of this effort.

Cooper, Henry S.F. *The Search for Life on Mars: Evolution of an Idea.* New York: Holt, Rinehart, & Winston, 1980. An encapsulation of the lure of Mars for Americans because of the hope that life might presently be found, or that it might have existed at some time in the past.

Digregorio, Barry E.; Levin, Gilbert V.; and Straat, Patricia Ann. *Mars: The Living Planet.* London, England: Frog, Ltd, 1997. A discussion of the possibilities of life on the Red Planet.

Ezell, Edward Clinton, and Ezell, Linda Neumann. *On Mars: Exploration of the Red Planet, 1958-1978.* Washington, DC: NASA Special Publication-4212, 1984. A detailed study of NASA's efforts to send space probes to Mars, culminating with the soft-landing of the two Viking spacecraft in the mid-1970s.

Fisher, David E. *The Third Experiment: Is There Life on Mars?* New York: Atheneum, 1985. A popular account of the Viking biology experiments that took place on Mars during the mid-1970s landings.

Glasstone, Samuel. *The Book of Mars.* Washington, DC: NASA Special Publication-179, 1968. This book explores the development of human knowledge about Mars, separating what was known through science, especially space science, and what has been handed down in myth. An excellent point of departure for any investigation of the scientific understanding of the planet, but now outdated because of the results of probes since 1968.

Goldsmith, Donald. *The Hunt for Life on Mars.* New York: E. P. Dutton, 1997. Discussion of recent findings and their implications.

Hansson, Anders. *Mars and the Development of Life.* New York: John Wiley & Sons, 1997, 2nd edition. Discussion of recent findings and their implications.

Hartmann, William K., and Raper, Odell. *The New Mars: The Discoveries of Mariner 9.* Washington, DC: NASA Special Publication-337, 1974. A description of the mission to Mars by Mariner 9 in the early 1970s.

Hoyle, Fred, and Wickramasinghe, Chandra. *Life on Mars? The Case for a Cosmic Heritage.* London, England: Clinical Press, Ltd., 1997. Discussion of recent findings and their implications.

Hoyt, William Graves. *Lowell and Mars.* Tucson: University of Arizona Press, 1976. Biography of Percival Lowell, pioneering American astronomer, examining his lifelong fascination with Mars and the possibility that it was once the home of intelligent life that built canals observable from Earth.

Keiffer, H.H.; Jakosky, B.M.; Snyder, C.W.; and Matthews, M.S. Editors. *Mars.* Tucson: University of Arizona Press, 1992. A detailed collection of scientific papers on the makeup and evolution of the Red Planet.

Ley, Willy, et al. *The Exploration of Mars.* New York: Viking, 1956. Illustrated by Chesley Bonestell, this is a large format book that posited the future exploration of Mars.

Lowell, Percival. *Mars.* Boston: Houghton Mifflin, 1895. Perhaps the earliest thorough study of the planet published in America, Lowell argued that the features viewed on the Martian surface were canals that perhaps carried water. This book discusses the astronomical information associated with Mars as it stood at the turn of the 20th century and posited that the canals might make life possible on the planet.

_____. *Mars and its Canals.* New York: Macmillan, 1906. Percival Lowell became interested in Mars during the latter part of the 19th century. Using personal funds and grants from other sources, he built what became the Lowell Observatory near Flagstaff, Arizona, to study the planets. This research led him to argue that Mars had once been a watery planet and that the topographical features known as canals had been built by intelligent beings. Over the course of the next 40 years, others used Lowell's observations of Mars as a foundation for their arguments. The idea of intelligent life on Mars remained in the popular imagination.

Matsunaga, Senator Spark M. *The Mars Project: Journeys Beyond the Cold War.* New York: Hill and Wang, 1986. Written by the then-senator from Hawaii, the author posits that in the post-Cold War era, cooperation rather than competition should inform space policy. In that context, he advocates the development of a cooperative mission to Mars with the United States and the former Soviet Union.

Moore, Patrick. *Guide to Mars.* New York: W.W. Norton and Co., 1977. A scientific discussion of what was then known about the planet, including an early discussion of the findings from the Viking project.

Mutch, T.A.; Arvidson, R.E.; Head, J.W.; Jones, K.L.; and Saunders, R.S. *The Geology of Mars.* Princeton, NJ: Princeton University Press, 1976. A detailed collection of scientific papers on the geology of the Red Planet.

Putnam, W.L. Editor. *The Explorers of Mars Hill: A Centennial History of Lowell Observatory.* Phoenix, AZ: Phoenix Publishing, 1994. This centennial history describes the origins and development of the observatory from its founding by Percival Lowell to the 1990s.

Raeburn, Paul. *Mars: Uncovering the Secrets of the Red Planet.* Washington, DC: National Geographic Society, 1998. A discussion of the latest findings with stunning visual images.

Richardson, Robert Shirley. *Exploring Mars.* New York: McGraw-Hill, 1954. Focusing on astronomy, this small book discusses the scientific knowledge available about the planet in the early 1950s.

_____, and Bonestell, Chesley. *Mars.* New York: Harcourt, Brace, and World, 1964. Illustrated by quintessential space artist Chesley Bonestell, this large-format book captures the excitement of Martian exploration and the possibilities of eventual colonization of the planet.

Sheehan, William. *The Planet Mars: A History of Observation & Discovery.* Tucson: University of Arizona Press, 1996. A survey of how humans have acquired knowledge about the Red Planet from antiquity to the present. It concentrates on the work of Earth-based astronomers but also includes succinct narratives of the Mariner 4 mission and the Viking project of the 1970s.

Slipher, E.C. *A Photographic History of Mars.* Flagstaff, AZ: Northland Press, 1962. A collection of early photographs taken of the planet, along with useful descriptions and analysis.

Stoker, Carol A., and Emmart, Carter. Editors. *Strategies for Mars: A Guide to Human Exploration.* San Diego, CA: Univelt, Inc., 1996. The most up-to-date and useful of several books related to Mars exploration, this collection of essays provides a rationale, technology assessment, and political analysis of the endeavor through the lens of an historical perspective.

Strughold, Hubertus. *The Red and Green Planet: A Physiological Study of the Possibility of Life on Mars.* Albuquerque: University of New Mexico Press, 1953. Strughold, a leading authority on space medicine in the 1950s, suggested it was possible that life existed and may still exist in some form on Mars.

Viking Lander Imaging Team. *The Martian Landscape.* Washington, DC: NASA SP-425, 1978. A scientific study of the results of the Viking project to Mars in the mid-1970s.

Washburn, Mark. *Mars at Last!* New York: G.P. Putnam, 1977. The first popular account of the Viking mission to Mars during which probes landed on the planet's surface.

Wilford, John Noble. *Mars Beckons: The Mysteries, the Challenges, the Expectations of Our Next Great Adventure in Space.* New York: Alfred A. Knopf, 1990. An in-depth explanation of the possibilities of Mars exploration including a discussion of earlier plans to send humans to the Red Planet.

Zubrin, Robert, and Wagner, Richard. *The Case for Mars: The Plan to Settle the Red Planet and Why.* New York: The Free Press, 1996. The author's explanation of why humans must travel to Mars as well as a scenario for how to do so at a reasonable cost and with technology presently available.

Pages 75–83 are duplicates of previous pages that are perforated and can be torn out for convenience.

National Standards for Arts Education (K–12)

http://artsedge.kennedy-center.org/cs/design/standards

1. Content Standard

Dance: Identifying and demonstrating movement elements and skills in performing dance.
Music: Singing, alone and with others, a varied repertoire of music.
Theater:

- K–4: Scriptwriting by planning and recording improvisations based on personal experience and heritage, imagination, literature, and history.
- 5–8: Scriptwriting by the creation of improvisations and scripted scenes based on personal experience and heritage, imagination, literature, and history.
- 9–12: Scriptwriting by improvising, writing, and refining scripts based on personal experience and heritage, imagination, literature, and history.

Visual Arts: Understanding and applying media, techniques, and processes.

2. Content Standard

Dance: Understanding choreographic principles, processes, and structures.
Music: Performing on instruments, alone and with others, a varied repertoire of music.
Theater:

- K–4: Acting by assuming roles and interacting in improvisations.
- 5–8: Acting by developing basic acting skills to portray characters who interact in improvised and scripted scenes.
- 9–12: Acting by developing, communicating, and sustaining characters in improvisations and informal or formal productions.

Visual Arts: Using knowledge of structures and functions.

3. Content Standard

Dance: Understanding dance as a way to create and communicate meaning.
Music: Improvising melodies, variations, and accompaniments.
Theater:

- K–4: Designing by visualizing and arranging environments for classroom dramatizations.
- 5–8: Designing by developing environments for improvised and scripted scenes.
- 9–12: Designing and producing by conceptualizing and realizing artistic interpretations for informal or formal productions.

Visual Arts: Choosing and evaluating a range of subject matter, symbols, and ideas.

4. Content Standard

Dance: Applying and demonstrating critical and creative thinking skills in dance.
Music: Composing and arranging music within specified guidelines.
Theater:

- K–4: Directing by planning classroom dramatizations.
- 5–8: Directing by organizing rehearsals for improvised and scripted scenes.
- 9–12: Directing by interpreting dramatic texts and organizing and conducting rehearsals for informal or formal productions.

Visual Arts: Understanding the visual arts in relation to history and cultures.

5. Content Standard

Dance: Demonstrating and understanding dance in various cultures and historical periods.
Music: Reading and notating music.
Theater:

- K–4: Researching by finding information to support classroom dramatizations.
- 5–8: Researching by using cultural and historical information to support improvised and scripted scenes.
- 9–12: Researching by evaluating and synthesizing cultural and historical information to support artistic choices.

Visual Arts: Reflecting upon and assessing the characteristics and merits of students' own work and the work of others.

6. Content Standard

Dance: Making connections between dance and healthful living.
Music: Listening to, analyzing, and describing music.
Theater:

- K–4: Comparing and connecting art forms by describing theater, dramatic media (such as film, television, and electronic media), and other art forms.
- 5–8: Comparing and incorporating art forms by analyzing methods of presentation and audience response for theater, dramatic media (such as film, television, and electronic media), and other art forms.
- 9–12: Comparing and integrating art forms by analyzing traditional theater, dance, music, and visual arts, and new art forms.

Visual Arts: Making connections between visual arts and other disciplines.

7. Content Standard

Dance: Making connections between dance and other disciplines.
Music: Evaluating music and music performances.
Theater:

- K–4: Analyzing and explaining personal preferences and constructing meanings from classroom dramatizations and from theater, film, television, and electronic media productions.
- 5–8: Analyzing, evaluating, and constructing meanings from improvised and scripted scenes and from theater, film, television, and electronic media productions.
- 9–12: Analyzing, critiquing, and constructing meanings from informal and formal theater, film, television, and electronic media productions.

8. Content Standard

Music: Understanding relationships between music, the other arts, and disciplines outside the arts.
Theater:

- K–4: Understanding context by recognizing the role of theater, film, television, and electronic media in daily life.
- 5–8: Understanding context by analyzing the role of theater, film, television, and electronic media in the community and in other cultures.
- 9–12: Understanding context by analyzing the role of theater, film, television, and electronic media in the past and the present.

9. Content Standard

Music: Understanding music in relation to history and culture.

National Research Council Science Content Standards (K–12)

http://bob.nap.edu/readingroom/books/nses/html/overview.html#content

1. Unifying Concepts and Processes
2. Science as Inquiry
3. Physical Science
   - K–4 (properties of objects and materials, position, and motion of objects, light, heat, electricity, and magnetism)
   - 5–8 (properties and changes of properties in matter, motions and forces, transfer of energy)
   - 9–12 (structure of atoms, structure and properties of matter, chemical reactions, motions, and forces, conservation of energy and increase in disorder, interactions of energy, and matter)
4. Life Science
   - K–4 (characteristics of organisms, life cycles of organisms, organisms, and environments)
   - 5–8 (structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, diversity and adaptations of organisms)
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   - K–4 (properties of Earth materials, objects in the sky, changes in Earth and sky)
   - 5–8 (structure of the Earth system, Earth's history, Earth in the solar system)
   - 9–12 (energy in the Earth system, geochemical cycles, origin and evolution of the Earth system, origin and evolution of the universe)
6. Science and Technology
7. Science in Personal and Social Perspectives
8. History and Nature of Science

NCTM Mathematics Content Standards (K–12)

http://standards-e.nctm.org/1.0/89ces/Table_of_Contents.html

1. Number and Operation (understand relationships among numbers, the meanings of operations, estimation, use of computational tools)
2. Patterns, Functions, and Algebra (understand types of patterns and functional relationships, use of symbols to represent/analyze mathematical situations, and the use of mathematical concepts)
3. Geometry and Spatial Sense (understand different representational systems [verbal, numerical, graphical, geometrical, or symbolic], use visualization and spatial reasoning to solve problems)
4. Measurement (understand units of measurement and apply a variety of techniques for determining measurements)
5. Data Analysis, Statistics, and Probability (pose questions, collect, organize, and represent data to answer these questions; interpret data, develop, and evaluate information based upon the data; understand and apply notions of chance and probability)
6. Problem Solving (build new mathematical knowledge; formulate, represent, abstract, and generalize; apply a wide variety of strategies to solve problems and adapt the strategies to new situations; monitor and reflect on their mathematical thinking in solving problems)
7. Reasoning and Proof (make and investigate mathematical conjectures and develop/evaluate mathematical arguments and proofs)
8. Communication (organize and consolidate their mathematical thinking to communicate with others; express mathematical ideas coherently; extend their mathematical knowledge by considering the thinking and strategies of others)
9. Connections (understand how mathematical ideas build on one another to produce a coherent whole; recognize, use, and learn about mathematics in contexts outside of mathematics)

10. Representation (create and use representations to organize, record and communicate mathematical ideas; use representations to model and interpret physical, social, and mathematics phenomena)

National Geography Standards (K–12)

http://www.nationalgeographic.com/education/xpeditions/main.html?STST=standards&STN=5

The World in Spatial Terms

1. How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective
2. How to use mental maps to organize information about people, places, and environments in a spatial context
3. How to analyze the spatial organization of people, places, and environments on Earth's surface

Places and Regions

4. The physical and human characteristics of places
5. That people create regions to interpret Earth's complexity
6. How culture and experience influence people's perceptions of places and regions

Physical Systems

7. The physical processes that shape the patterns of Earth's surface
8. The characteristics and spatial distribution of ecosystems on Earth's surface

Human Systems

9. The characteristics, distributions, and migration of human populations on Earth's surface
10. The characteristics, distribution, and complexity of Earth's cultural mosaics
11. The patterns and networks of economic interdependence on Earth's surface
12. The processes, patterns, and functions of human settlement
13. How the forces of cooperation and conflict among people influence the division and control of Earth's surface

Environment and Society

14. How human actions modify the physical environment
15. How physical systems affect human systems
16. The changes that occur in the meaning, use, distribution, and importance of resources

The Uses of Geography

17. How to apply geography to interpret the past
18. How to apply geography to interpret the present and plan for the future

Registration Information: Sample Worksheets

Virtual Gallery: Part 1
On-line Registration Information

Use this worksheet to prepare information for your on-line submission.

_____

Mission Name
(Use up to a total of 20 letters and numbers, including spaces. Please do not use symbols or punctuation.)

_____

Project Team Supervisor's Name

_____

School or Organization

_____

Grade Level

_____

Address

_____

City *State* *Zip*

_____

Phone *Fax*

_____

E-mail

Virtual Gallery: Part 2

Project Description

Use this worksheet to prepare information for your on-line submission.

Describe Your Work
To better understand how you imagined your community, *Mission Control* would like to know about the issues and challenges your *Project Team* confronted while integrating art, science, and culture in designing your Mars community. For the project summary section, write a description of your *Project Team's* community: what artistic, scientific, and technical challenges you faced in creating it; what you learned about your own community; and what you hope for the future. *Project Team* members should collaborate on the summary with discussion and debate to reach conclusions that represent the group's project. You may want to designate one *Mission Specialist* to record these ideas and write the project summary.

Limit your submission for the project summary to 500 words or less.

Answer the following questions, as well as any others that may have come up as you completed your project:

- How did you make your community livable?
- How did you make it an inviting place to live and work?
- How did you organize and manage your community?
- What did it mean to be a citizen in your community?
- What major artistic inspirations did you have?
- What major technical and scientific factors did you take into account?
- What did you learn about the community around you?
- What do you want the community of the future to be like?

Once completed, use the space provided on the on-line submission form to enter your ideas.

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Virtual Gallery: Part 3

Photograph of Your Project

Use this worksheet to prepare information for your on-line submission.

Exhibit Your Work
The *Mars2030 Virtual Gallery* is where ideas and creations of *Mission Specialists* and *Project Teams* will come together in the on-line environment.

Project Teams will submit their registration information along with their ideas and visual representation.

Mission Control is interested in understanding the design and appearance of your *Mars2030* community. Create a visual representation of the entire community designed by your *Project Team,* or any artistic or scientific element or aspect of your new community.

For example, this representation might be (but is not limited to):
- a constructed model of the *Mars2030* community;
- a computer generated two or three dimensional design;
- a work of art—two-dimensional drawing, painting or other artwork; a three-dimensional sculpture, diorama, or other artistic visual representation;
- performance art—a dance, theatrical presentation, opera, orchestral, or choral presentation; or
- a visual representation of an equation, science fair project, theory.

Remember, this project is full of variety and answers to questions in many forms employing the arts, sciences, and technology. It can show (but is not limited to) your entire community, a small portion or a component of your community, or it can be something a member of your community might create.

To submit your project to the *Virtual Gallery,* please photograph your visual representation, using slide (35mm transparency) film or digital camera to create your community's homepage, then go to *www.mars2030.net,* click *"Virtual Gallery,"* and follow the directions shown there. Submitting a link to a *Web site* containing your *Data Form* does not constitute submission of the *Data Form.*

Below, describe in a few sentences what this slide shows.

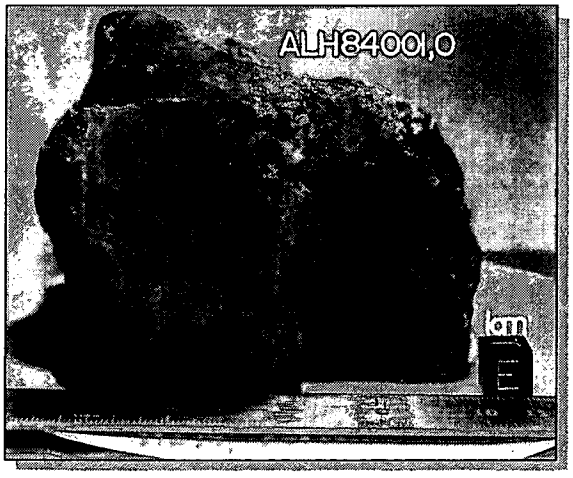
Why Mars?

Of all the planets in our solar system, Mars is the most like Earth. With a thin atmosphere, weather, seasons, and a 25-hour day, Mars has a diverse and complex surface, including ice and winding channels made by flowing water in the distant past. Although the cold, dry conditions on Mars may not support life now, scientists believe that Mars was warmer, wetter, and had a much denser atmosphere early in its history. Life may have arisen in ancient martian lakes or springs. If so, fossil evidence of life might be found.

Mars has experienced a complicated geologic history. On its surface are vast expanses of sand dunes, gorges carved by running water, polar ice caps, huge volcanos, and gigantic canyons. The giant Olympus Mons volcano is three times as tall as Mt. Everest and larger than Montana; it's the largest volcano in the solar system. Valles Marineris is three times as deep and 10 times as long as the Grand Canyon.

Mars was not always the dry wasteland it is now—it was once graced by lakes and possibly even rivers and an ocean. Learning how and why Mars' climate changed will help us understand our Earth's climate and how it might change in the future.

With a land area equal to Earth's, Mars offers a wealth of natural resources. The essentials for life support, including air and water, can be found or manufactured on the martian surface. These resources will be essential for humans to live and work on Mars as we continue to explore the Red Planet.



Evidence for Ancient Life on Mars?

In August 1996, a team of researchers announced that they had found possible bacterial fossils in a meteorite from Mars. This meteorite formed on Mars about 4 billion years ago, and was blasted off Mars by an asteroid impact. After leaving Mars, the meteorite finally landed on Earth in the Antarctic, where it was found by a U.S. expedition. The possible martian fossils in the meteorite are shaped like Earth bacteria and were found with minerals and organic chemicals that occur with Earth bacteria. Many scientists are not convinced that the possible fossils really are fossils, and it will probably take a few years to find out whether the bacteria shapes really are relics of ancient life on Mars.

The picture above shows the martian meteorite ALH 84001, home to the possible martian bacteria fossils. The picture on the right is a scanning electron microscope image of the bacteria shapes inside that meteorite. These shapes might be fossils of ancient martian life, but might also have formed without any living things.

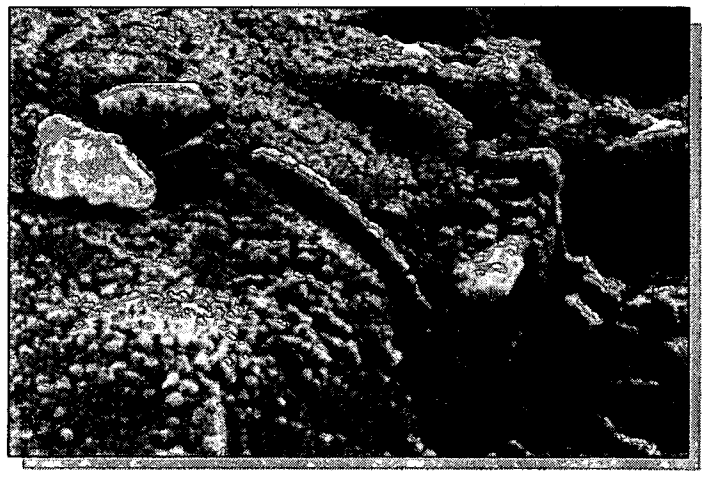


IMAGE DESCRIPTIONS

BACKGROUND IMAGE—

Mosaics of Mars were created by geologists from the U.S. Geological Survey, Flagstaff, Arizona from Viking 1 orbiter data gathered in 1980. Individual images are combined into a "point perspective" projection that gives a view of Mars as you might see it from a spacecraft window 2500 kilometers (1500 miles) above the surface. [Courtesy U.S. Geological Survey; images have been purposely reduced in density for this poster.]

POSTCARDS...(TOP TO BOTTOM)—

Flood Channel

—Although Mars is very dry, it probably has lots of water inside, both as liquid groundwater and as ice in frozen ground. The underground water escapes sometimes in giant floods, and carves channels like this one, called Ravi Vallis. The water erupted from the hilly area to the right (west) and surged eastward, cutting a deep channel with streamlined mounds on its floor. This scene is about 75 kilometers across. (Viking Orbiter image 014A69, view looking south, colorized.)

Valles Marineris Wall

—The Valles Marineris canyons are longer and deeper than any on Earth. The whole Valles system stretches 5000 kilometers across Mars (as far as from New York to Los Angeles) and this view of the Valles wall is about 550 kilometers long (from New York to Washington D.C.). The Valles here is eight kilometers deep, from the plateau at the upper left to the canyon floor at the bottom. The Grand Canyon is only about one and a half kilometers deep. If the Earth's tallest mountain, Mt. Everest, were put on the Valles bottom here, its peak would just rise above the plateau elevation. If the tallest mountain in North America (Mt. McKinley) were put at the canyon bottom, its summit would only be two-thirds of the way up to the canyon rim. (Viking Orbiter image 057A27, view looking north, colorized.)

Landslide in Valles Marineris

—Although the huge canyons of the Valles Marineris originated as tectonic structures (the crust pulled apart), they have been modified by other processes, like the landslide on the south wall of Valles Marineris shown here. This landslide partially removed the rim of the crater that is on the plateau adjacent to Valles Marineris. Notice the texture of the landslide deposit where it flowed across the floor of Valles Marineris. Several distinct layers can be seen in the walls of the trough. These layers may be regions of distinct chemical composition or mechanical properties in the martian crust. The image is 60 kilometers across. (Viking Orbiter image 14A30, view looking south, colorized.)

Frost at the Viking 2 Lander (48°N,226°W)

—Viking Lander 2 is far enough north that frost deposits may form on the surface during winter. This image, taken in May 1979, shows a thin, white layer of water frost, estimated to be only micrometers (1 micrometer = 0.001 millimeters) thick, covering parts of the surface. The reddish regions are soil and rock not covered by the frost. Portions of the spacecraft are visible in the right foreground. (Viking Lander image 21I093.)

Polar Ice Cap

—Like the Earth, Mars has ice caps at its north and south poles. This wind-carved canyon shows layers of clean white ice and brownish dusty ice, like tree rings, beneath the surface of Mars' north ice cap. The layers preserve a history of the ice cap. The brownish layers probably formed when Mars was a bit warmer than now, and dust from huge storms mixed into the ice. This scene is about 55 kilometers across. (Viking Orbiter image 077B24, view looking north, colorized.)

MARS FACTOIDS

Fourth Planet From the Sun

Distance From the Sun:
Minimum: 206,000,000 kilometers
Average: 228,000,000 kilometers (1.52 times as far as Earth)
Maximum: 249,000,000 kilometers

Eccentricity of Orbit:
0.093 vs. 0.017 for Earth (0.00 is a perfectly circular orbit)

Distance From Earth:
Minimum: 56,000,000 kilometers
Maximum: 399,000,000 kilometers

Year:
1.88 Earth years = 669.3 Mars days (sols) = 686.7 Earth days

Day:
24.6 Earth hours

Tilt of Rotation Axis:
25.2° vs. 23.5° for Earth

Size:
Diameter = 6794 kilometers vs. 12,756 kilometers for Earth
Surface Gravity: 0.38 (or ~1/3) Earth's gravity
Mass: 6.4×10^{26} grams vs. 59.8×10^{26} grams for Earth
Density: 3.9 grams/cc vs. 5.5 grams/cc for Earth

Surface Temperature:
Cold
Global extremes: –125°C (–190°F) to 25°C (75°F)
Average at Viking 1 site: high –10°C (15°F); low –90°C (–135°F)

Atmosphere:
Thin, unbreathable
Surface pressure: ~6 millibars, or about 1/200th of Earth's
Contains 95% carbon dioxide, 3% nitrogen, 1.5% argon, ~0.03% water (varies with season), no oxygen. (Earth has 78% nitrogen, 21% oxygen, 1% argon, 0.03% carbon dioxide.)
Dusty, which makes the sky pinkish. Planet-wide dust storms black out the sky.

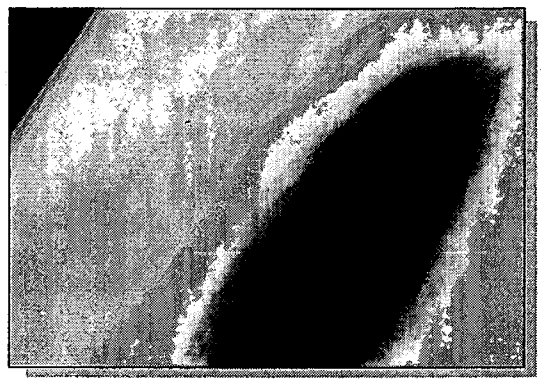
Surface:
Color: Rust red
Ancient landscapes dominated by impact craters
Largest volcano in the solar system (Olympus Mons)
Largest canyon in the solar system (Valles Marineris)
Ancient river channels
Some rocks are basalt (dark lava rocks); most others unknown
Dust is reddish, rusty, like soil formed from volcanic rock

Moons:
Phobos ("Fear"), 21 kilometers diameter
Deimos ("Panic"), 12 kilometers diameter

MARS MYSTERIES

Even though we have begun to explore Mars with robotic spacecraft, the Red Planet still remains mysterious. There are plenty of questions for humans and machines to unravel in the coming years. Here is a sampling of some of the puzzles of Mars.

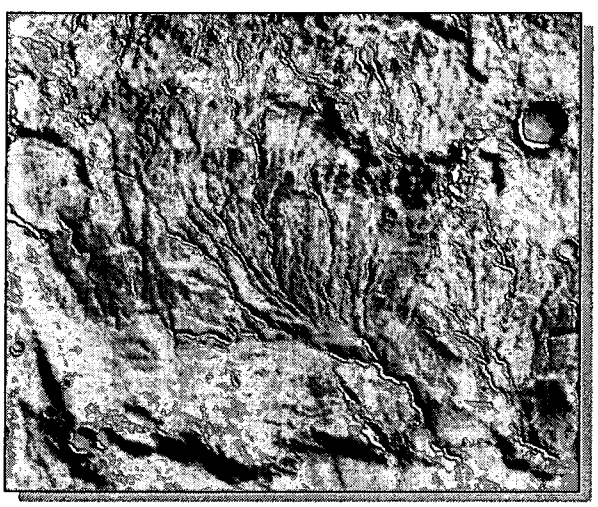
Why Are Some Features So BIG?



The volcano Olympus Mons (27 kilometers tall and 600 kilometers across, pictured) is the largest in the solar system, and other giant volcanos in the Tharsis region actually form an unusual bulge on the small planet. Valles Marineris, the enormous canyon system, would stretch across the continental United States. Scientists believe that the way heat escapes from Mars as it cools causes a different style of tectonic activity than we see on our own planet. On Earth, crustal plates spread apart and collide, continually reshaping the surface and sliding over hotspots welling up from the planet's interior. But Mars seems to be a "one-plate planet" with very little horizontal movement at the surface (with the exception of the giant canyon, of course!). How this style of tectonics works and how it produces the colossal features of the martian landscape are still unsolved mysteries.

Where Did All the Water Go?

The martian landscape shows unmistakable signs of water flowing on its surface—from branching networks of river channels (pictured) to streamlined islands to great gouges caused by sudden catastrophic floods.



Water ice is present in the polar caps of the planet today, and the Viking 2 lander photographed water frost covering the ground in the predawn light at its landing site. Some scientists believe Mars may once have had enough water to make an ocean kilometers deep! Today, the martian surface is a desert; the atmosphere is too thin and the temperature too cold to allow liquid water to exist. What happened to the once-abundant water, and why? Some must certainly have escaped to space as the small planet cooled and the climate changed. But water might still exist in underground pools of groundwater or be locked into the pores of subsurface rock as permafrost. Finding out how much water exists and where it is will be an important goal of future explorations. The answer may determine whether humans will ever live and work on Mars.

What Happened to the Atmosphere?

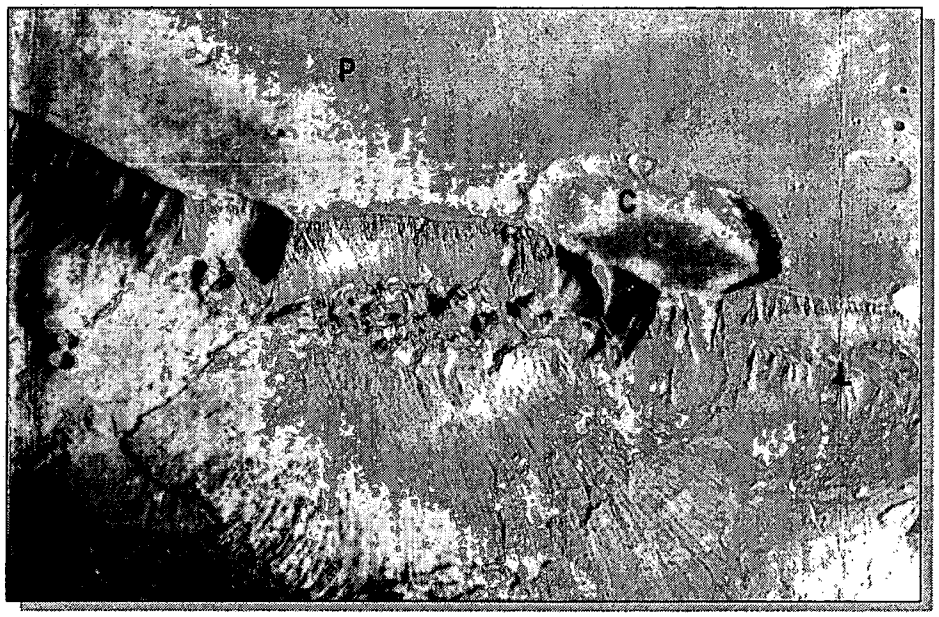
The evidence that liquid water was once abundant on the surface also means that Mars once had a much denser, warmer atmosphere. But atmospheric pressure now is less than one percent of Earth's, and the temperature is too cold for liquid water to exist. Water frosts and ice simply evaporate into the atmosphere, and form again when the seasonal temperature drops. What caused Mars to lose its once thicker, warmer atmosphere? Because Mars is small with a surface gravity only about one-third of Earth's, some of that atmosphere must have been lost to space. But scientists still seek to understand exactly how and why Mars' climate has changed so drastically over time and how rapid those changes were. The answers to these questions will tell us whether it is likely that some sort of life had time to develop under hospitable conditions.

ACTIVITY 1: "OLD, RELATIVELY"

For exploring Mars, it is important to know which events happened in which order and which areas are older than others. A simple way of figuring out the sequence of events is "superposition" – most of the time, younger things are on top of older things, and younger (more recent) events affect older things.

Superposition in Your Life

Is there a pile of stuff on your desk? On your teacher's? On a table or floor at home? Where in the pile is the thing you used most recently? The next thing used most recently? Where in the pile would you look for something you put down 10 minutes ago? When was the last time you or your teacher or parent used the things at the bottom of the pile?



Superposition on Mars

Using superposition, we can sort out many of the complicated events in the history of Mars. For example, you can sort out all the events that affected the area in the image above (also on the front of this poster). It is a small part (60 kilometers across) of the wall of the great canyon system of Valles Marineris. Toward the top is a high plateau (labeled "P"), with a large circular impact crater ("C"). It formed when a huge meteorite hit Mars' surface. Below the plateau is the wall of Valles Marineris. Here, the wall has been cut away by huge landslides ("L"), which leave bumpy rough land at the base of the wall and a thin, broad fan of dirt spreading out onto the canyon floor. In the canyon wall, almost at its top, alternating layers of light and dark rock are exposed.

To discover the history of this region, start by listing all the landscape features you can see, and the events that caused them (don't bother listing every small crater by itself). Now list the events in order from oldest to youngest. [Hints: How many separate landslides are there? Is the large crater ("C") younger than the landslides? Are the landslides younger than the rock layers at the top of the canyon wall? Are the small craters older or younger than the landslides?] Sometimes, you cannot tell which of two events was younger. What additional information would help you tell?

To learn more about this image, visit the World Wide Web site at:
http://cass.jsc.nasa.gov/education/K12/gangis/mars1.html

ACTIVITY 2: "GEOGRAPHY AND MISSION PLANNING"

Latitude	Longitude	
22°N	48°W	(Viking Site)
20°N	108°E	
44°N	10°W	
7°S	43°W	
46°N	150°W	(Viking Site)
44°N	110°W	
5°S	5°W	

These locations on Mars were considered by mission planners as possible landing sites for the two Viking landing craft.

If martians sent spacecraft to these same latitudes and longitudes on Earth, what would they find? Would they find life or evidence of an advanced civilization? Use a globe or world map to identify these spots on Earth. Use geography reference books to describe what the martians would see at each site.

If you were a martian, why would you explore Earth? Does Earth have resources you might need? What would you want to know about the Earth? Where would you land first and why?
—(From B.M. French, The Viking Discoveries, NASA EP-146, October 1977)

For Reference: Mars Map

U.S. Geological Survey (1991) Topographic Maps of Polar, Western, and Eastern Regions of Mars, U.S. Geological Survey Miscellaneous Investigations Map I-2160. USGS Information Services, 1-800-USA-MAPS

WEBSITES

Mars

Ames Center for Mars Exploration	**http://cmex-www.arc.nasa.gov/**
Hubble Space Telescope Images of Mars	**http://www.stsci.edu/pubinfo/PR/95/17.html**
Lunar and Planetary Institute	**http://cass.jsc.nasa.gov/expmars/expmars.html**
Mars Multi-Scale Map	**http://www.c3.lanl.gov/~cjhamil/Browse/mars.html**
Mars Global Surveyor Project	**http://spacelink.nasa.gov/NASA.Projects/S.Science/Solar.System/Mars.Global.Surveyor/**
Mars Pathfinder Project	**http://mpfwww.jpl.nasa.gov/**
Mars K-12 Curriculum Guide (Arizona State University)	**http://esther.la.asu.edu/asu_tes/TES_Editor/CURRIC_GUIDES/curric_guideMENU.html**
Mars Surveyor Orbiter	**http://mars.jpl.nasa.gov/msp98/news/news4.html**
Mars Surveyor Lander	**http://mars.jpl.nasa.gov/msp98/lander/**
Viking Orbiter Image Archive	**http://barsoom.msss.com/http/vikingdb.html**
Viking Lander Image Data	**http://www-pdsimage.jpl.nasa.gov/PDS/public/vikingl/vl_images.html**

Tours of the Solar System

Views of the Solar System	**http://www.athena.ivv.nasa.gov/curric/space/planets/index.html**
The Nine Planets (Bill Arnett/SEDS)	**http://seds.lpl.arizona.edu/nineplanets/nineplanets/nineplanets.html**
Welcome to the Planets (JPL)	**http://pds.jpl.nasa.gov/planets/**

Education

NASA On-line Resources for Educators	**http://www.hq.nasa.gov/education**
Lunar and Planetary Institute	**http://cass.jsc.nasa.gov/**

ACTIVITY 3: "THE SHADOW OF PHOBOS"
(MATHEMATICS AND CONCEPTS FOR UPPER GRADES)

1. How Fast Do Mars' Moons Move? The two moons of Mars, Phobos and Deimos, were discovered in 1877 by Asaph Hall. He measured how far they were from Mars, and so learned the size of their orbits. By watching the moons as they moved, he also measured how long each took to orbit Mars, (its orbital period). Because they are close to Mars, they move very fast.

How fast do Phobos, Deimos, and our own Moon move? To calculate their speeds, remember that:
speed = distance/time, and that the distance around a circle is 2π x radius.

Moon	Radius of Orbit (km)	Orbit Period (Earth days)	Orbit Period (seconds)
Phobos	9,380	0.32	2.75×10^4
Deimos	23,500	1.26	1.1×10^5
Moon	384,400	27.33	2.4×10^6

2. How Much Does Mars Weigh? Back in the 1600s, Isaac Newton proved that the speed of a moon was related to the mass of its planet and its distance from the planet:

$$M = \frac{rv^2}{G}$$

where M is the mass of the planet (kilograms), v is the moon's speed (kilometers/second), r is the radius of the moon's orbit (kilometers), and G (the universal gravitational constant) is $6.67 \times 10^{-20} kg^{-1} km^3 s^{-2}$. So, with the data and speeds you calculated above, what is Mars' mass? How massive is Mars compared to the Earth?

3. Phobos in the Sky With Deimos. Both Mars and the Earth rotate so that the Sun rises in the east and sets in the west, and their moons all orbit in the same direction as the planets rotate. Earth's Moon has a very long orbital period compared to the length of an Earth day, so on a given day our Moon moves east to west across the sky with minor movement relative to the sun or stars. However, this is not the case for Mars' moons. By comparing their orbital periods with the length of a martian day (1.026 Earth days), determine how the martian moons will appear to move across the sky to an observer on the surface. [Hint: Sketch how the orbits of Mars and its moons look to an observer looking down at Mars from very far above Mars' north pole. From this view, Mars rotates counterclockwise, and its moons orbit counterclockwise.] In one Mars day, Mars rotates on its axis once. In that Mars day, how many times do Phobos and Deimos go around Mars?.

4. The Shadow of Phobos. You are standing on the equator of Mars at noon and Phobos, about 21 km in diameter, passes directly overhead. How long will you be in the shadow of Phobos? To figure this out, compare the velocity of Phobos in orbit to your velocity on the equator of Mars, 0.2405 km/s, and calculate the velocity of Phobos relative to you. The time you will be in shadow is simply the length of Phobos' shadow divided by its velocity relative to you.

ACTIVITY 4: "CANYONS AND VALLES MARINERIS"

The great canyon of Valles Marineris stretches 4000 kilometers across Mars. The image below shows part of Ius Chasma, the southwestern part of the Valles Marineris.

Working for Scale (Geography and Math)

The scene in this picture is 600 kilometers east-to-west (left to right) viewed from directly overhead. At this scale, how many centimeters (or inches) on the picture represent 100 kilometers on Mars? How many kilometers from top to bottom of the scene? How big is the largest circular impact crater you can see? How far is it across your home town?

Sketch the outline of your home state at this scale. Would it fit inside Ius Chasma? Which states would fit inside? Ius Chasma is about five kilometers deep. For comparison, how tall (in kilometers) is Mt. Everest, the tallest mountain on Earth? How tall is Mt. McKinley (Denali), the tallest in North America?

Find a map of Arizona or the western U.S. that shows the Grand Canyon. Trace the path of the Colorado River as it flows through the Canyon. Now redraw your tracing at the same scale as this picture of Ius Chasma. Which canyons in Ius Chasma are comparable in size to the Grand Canyon? How wide is the Grand Canyon, and how wide are the canyons on the south side of Ius Chasma?

(Advanced) Imagine you are standing on the floor of Ius Chasma at its south wall at the very eastern edge of the picture. How tall does the north wall of the Chasma appear to be? As tall as a telephone pole seen from a block away? Did you consider that Mars is a spherical planet (more or less) and its surface is curved?

Straight and Crooked Paths

Ius Chasma is basically straight because its edges follow huge geologic faults. On a map of your home state, trace out the channels of rivers and streams; are any straight like Ius Chasma? From a map of Arizona, examine the main channels and canyons in the Grand Canyon. Is the Grand Canyon as crooked as the canyons on the south wall of the Chasma? Find the East African Rift on a topographic map of Africa. The Rift's walls are huge geologic faults—are any parts of the rift as long and straight as Ius Chasma?

MORE ABOUT MARS

BOOKS

Beatty, J.K., and A. Chaikin, eds. (1990) *The New Solar System*, Third Edition, Sky Publishing Corp., Cambridge.

Carr, M.H. (1981) *The Surface of Mars*, Yale University Press, New Haven. A highly readable account of our knowledge of Mars at the end of the Viking program.

Christiansen, E.H., and W.K. Hamblin (1995) *Exploring the Planets*, Second Edition, Prentice Hall, Englewood Cliffs, New Jersey.

Cooper, H.S.F. (1980) *The Search for Life On Mars: Evolution of an Idea*, Holt, Rinehart, and Winston, New York.

Lowell, P. (1895) *Mars*, Houghton, Mifflin, Boston, New York. Percival Lowell's fascinating, passionate, and highly erroneous interpretations of his longtime observations of Mars. Especially interesting when read with Sheehan's *Planets & Perception*.

Murray, B. (1989) *Journey Into Space: The First Thirty Years of Space Exploration*, W.W. Norton, New York. Describes humankind's robotic exploration of Mars and the rest of the solar system, as witnessed by this former director of the Jet Propulsion Laboratory.

Sheehan, W. (1988) *Planets & Perception: Telescopic Views and Interpretations, 1609–1909*, University of Arizona Press, Tucson. An introduction to the physical, social, and psychological pitfalls of observing distant worlds, especially Mars. This makes an excellent companion to Lowell's *Mars*.

Sheehan, W. (1996) *The Planet Mars: A History of Observation and Discovery*, University of Arizona Press, Tucson. A popular history of discoveries and ideas about Mars, emphasizing the era of visual and telescopic observations.

Viking Lander Imaging Team (1978) *The Martian Landscape*, NASA SP 425. A compilation of photographs obtained by the Viking Landers.

Viking Orbiter Imaging Team (1980) *Viking Orbiter Views of Mars*, NASA SP 441. A compilation of photographs obtained by the Viking Orbiters.

Wilford, J.N. (1990) *Mars Beckons*, Alfred A. Knopf, New York.

SCIENCE FICTION

Since telescopes first revealed seasonal color changes on Mars, Earthlings have been fascinated with the possibility of life on the Red Planet. These classics (among hundreds of others) trace human notions of martian "society" through the 20th century and hold up a mirror to the concerns and crises of our own.

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